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Hoisting a section of a funnel into place on an Atlantic liner.

THE BIG ATLANTIC LINERS.—[See page 260.]

Modern Research in the Metallurgy of Iron—I*

How Wonderful New Qualities and Properties Are Being Developed

By Allerton S. Cushman, Director, The Institute of Industrial Research, Washington, D. C.

Of all the seventy or eighty elements of which the materials of the universe, as revealed and proved by the spectroscope and chemical research, are found to be made, there is none so interesting to mankind as iron.

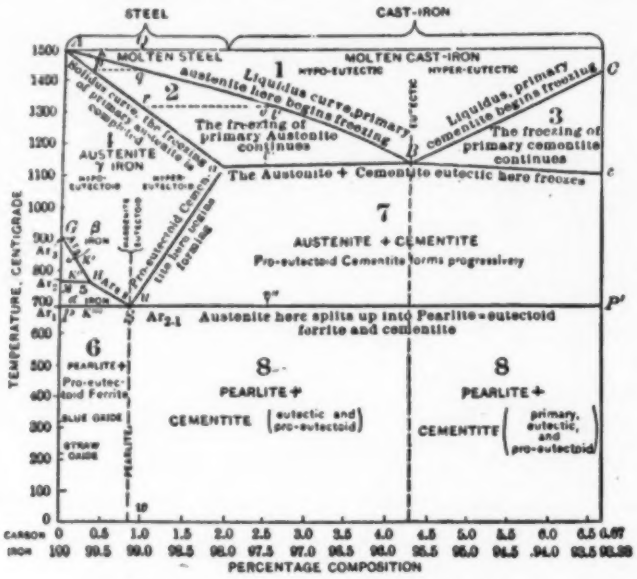


Fig. 1.—The carbon-iron diagram (Howe).

The terms "iron" and "steel" are more or less vaguely differentiated, both by the layman and the professional metallurgist. Therefore, before proceeding further with our subject, it will be well if we understand, at least for the time being, just what we mean by these terms. There is a difference of opinion even among scientific men who have spent their lives in metallurgical research in regard to the exact definitions of the words "iron" and "steel." For our present purposes, however, let us take refuge in the common definitions as given in the dictionary, to which the layman of the world turns for information in regard to the meaning of the words which he employs. Webster's New Century Dictionary defines iron very simply as the most common and useful of the metals, and this same authority defines steel as refined iron combined with carbon. These definitions, which the writer accepts as true ones both from the standpoint of common usage and scientific interpretation, lead us naturally to the introduction of the subject under discussion in this paper, namely, modern research in the metallurgy of iron and steel. Before proceeding further into our subject, however, it is necessary to pause long enough to point out that research work can be classified very readily under separate headings. In ancient times research work into the capabilities of metallic iron was confined to the wonderful old smiths and artisans who produced, by the crudest means, examples of hardened steel whose qualities and character challenge the admiration of, and, perhaps, even to some extent defy imitation by, modern methods. All that the ancient artisan found out he usually kept to himself, or at best he divulged his secrets only to his own apprentices and immediate disciples. With this form of research work we are not at present concerned. Modern scientific methods, however, can be considered under two main heads which I shall distinguish as plant and laboratory research. When Bessemer and his contemporaries, some fifty or sixty years ago, conceived the idea of refining iron on the large scale of operation by the pneumatic process, that is to say, by blowing air under pressure through a mass of molten metal, the experimental work could only be done upon the plant scale of investigation, with its attendant difficulties, enormous cost, and danger. It has been, comparatively speaking, only within the last two decades that laboratory research in iron metallurgy has come to the assistance of the clumsier and more cumbersome method of plant scale investigation. It must at once become apparent that the most useful and the richest field is opened up where the laboratory investigator and the man who knows how to work enormous masses of metal at high temperatures join hands with a common purpose in view.

As has already been suggested, one of the extraordinary characteristics of iron depends upon the fact that it possesses an affinity for the element carbon, and combines with small quantities of this element in such a manner as to completely change its inherent characteristics. In other words, iron dissolves and seeks to dissolve in itself carbon, and it is this tendency which bears within itself potentialities of a most wonderful and extraordinary nature. I can best introduce this particular phase of the subject by making reference to what is known to metallurgists as the *Carbon-iron diagram*, which has been accurately worked out by research students, and which as completely maps the possibilities lying within the combination of cast iron on the one hand and pure iron and high carbon steels on the other, as the geographical map is capable of placing before us a broad purview of the whole or a portion of the earth's surface. This diagram has been worked out with the aid of the microscope and by modern pyrometric methods for measuring high temperatures, even as high as those known to exist in the sun, with great accuracy, both lines of research representing to a great extent a very modern development.

The carbon-iron diagram, as worked out in its entirety by our own distinguished metallurgist, Henry M. Howe, is shown in Fig. 1. For the sake of simplicity a detail of a portion of the diagram is shown in Fig. 2.

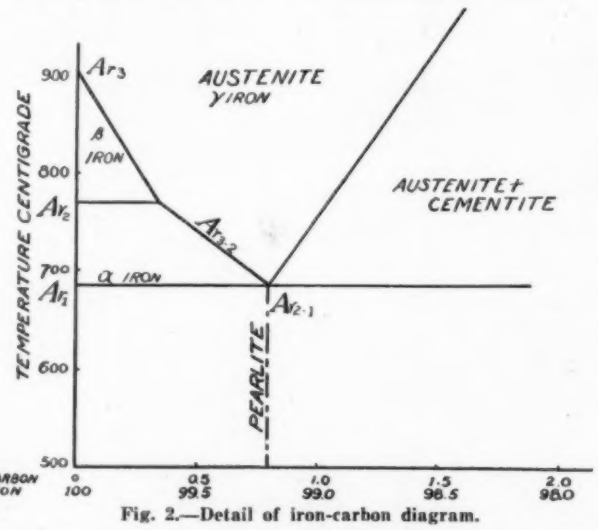


Fig. 2.—Detail of iron-carbon diagram.

I cannot attempt, in the limited time allotted to me, to elucidate all that the iron-carbon diagram has opened up to us, but must content myself with pointing out some interesting and salient features.

It has been known for a long time that if we heat iron or steel gradually until we arrive at the melting point of the metal, the rate of heating does not proceed uniformly. In the same way, if we start with iron or steel in the molten condition and cool it gradually, in both cases, at certain fixed temperatures, retardations in heat changes occur. These points are known as "critical points" or "critical temperatures." They are unquestionably caused by physical changes whereby heat is liberated at the critical points on cooling, or absorbed on heating. The three principal critical points which have been mapped are designated as A_1, A_2, and A_3. On account of molecular inertia or lag, these changes occur at lower temperatures on cooling down than on heating up, unless the rates of heat changes are infinitely slow. To distinguish them, the cooling points are designated as AR_1, AR_2, and AR_3, while the heating points are written AC_1, AC_2, and AC_3. So decided are some of these extraordinary liberations of heat that the temperature of the cooling mass may be even raised slightly, and, when the observer is in the dark, a sudden glowing may be seen. This phenomenon is termed recalescence, and has been made the subject

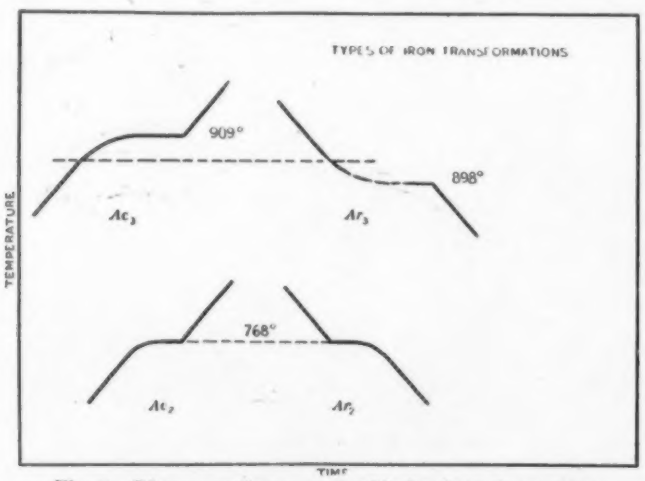


Fig. 3.—Diagrammatic curve of critical points of pure iron.

* Read before the Franklin Institute and published in the *Journal* of the Institution.

of much research work and inquiry, a number of theories having been advanced to explain what takes place. The commonly accepted explanation is that iron exists in at least two, and possibly three, allotropic modifications, and that the heat which is given off or absorbed, as the case may be, represents the energy of atomic rearrangements which are taking place.

A very familiar example of an element which exists in several allotropic modifications, without changing its chemical constitution, is that of ordinary carbon. One allotropic form of this element is the diamond, while a piece of charcoal or a piece of graphite may represent two other allotropic modifications. In the same way, then, we are to understand that iron is capable of existing in different modifications, and that these interesting critical points are simply the temperature points at which these changes of form take place. According to the best authorities, as described by G. K. Burgess:[1]

"The question of the allotropy of iron, in spite of a vast amount of experimental work and perhaps an even greater amount of theorizing, is not yet settled. That there is a definite transformation in iron near 900 degrees, the A_3 point, is generally recognized, as well as the fact that the temperature of this transformation is lowered by the addition of carbon and metallic elements. On heating the transformation Ac_3 is always found at a higher temperature than the transformation Ar_3 on cooling. Whether the A_3 transformation is sharp, like the melting-point of a pure substance, or extends over a considerable range of temperatures, embracing perhaps at a lower limit the A_3 change, appears to be still an open question for pure iron. The nature and identity of the A_3 transformation, it would appear from recent publications, has not yet been satisfactorily settled."

It seems at least to be generally conceded that the critical points A_3 and A_2 divide iron into separate allotropic forms. These are defined as α, β, and γ iron. γ iron exists above A_3 and α iron below A_2. The A_2 point may or may not be another transition point, so that at the present time the existence of a β modification between A_3 and A_2 is in debate. The subject is too involved for discussion in this paper, but in any event it is certain that an interesting change or transformation takes place at the point A_2 which is associated mainly with the loss of the interesting property of magnetism which α iron exhibits. If chemically pure iron is the material under investigation, these critical points can be simply plotted on a diagrammatic curve, as published by G. K. Burgess and his co-workers, and shown here in Fig. 3. When steels of varying composition are under consideration, however, these critical points, as shown on the iron-carbon diagram, indicate all sorts of interesting changes which may take place.

That branch of metallurgy which treats of the constitution and structure of metals and alloys is known as metallography, and, with the aid of the microscope in the hands of research students, a number of different definite constituents of iron and steel have been distinguished, studied, and named. Among these constituents it is necessary to define the following.

Ferrite is the name applied to pure iron, and is employed to designate that part of iron or steel which is not in combination with carbon, but which may have crystallized out from a solidifying mass, in the practically pure condition. Ferrite is easily recognized under the microscope by its characteristic grain.

Cementite is the name given to a carbide of iron having a definite formula (Fe_3C). It represents a normal carbide of iron which also crystallizes out as a molten mass of carbon steel solidifies.

If a solution of common salt in water, such as sea water, is cooled at certain temperatures, depending upon the percentage of salt present, either salt or ice commences to crystallize out, and this action continues until the remaining solution, called the "mother liquor," has a definite composition, when it finally freezes out together in a mixture of minute plates of alternate ice and salt, which is scientifically known as cryo-hydrate. Whenever a similar action takes place in the cooling and freezing of molten alloys, the terms "mother metal" or "magma" and "eutectic" are substituted for mother liquor and cryo-hydrate, respectively. An interesting constituent which is always found in ordinary carbon steels which have been cooled in the usual way is a eutectoid or eutectic-like substance, consisting of a mixture of alternate minute plates of ferrite and cementite crystallized out. When a sample of the solidified steel is highly polished and slightly etched with an acid body and examined under the microscope, this constituent appears as a pearly iridescent substance, and is known to metallurgists by the appropriate name of *pearlite*. These separate substances, which we have defined as ferrite, cementite, and pearlite, are the three most important constituents of steel which are ordinarily considered. The amount of pearlite, ferrite, or cementite, in different compounds of iron and carbon, as shown graphically by O. M. Becker,[2] a well-known authority, is given in Fig. 4. The line of abscissæ here represents the amount of carbon present and the ordinates the amount of the three constituents. In addition to these constituents, however, the research student of iron and steel has to take into consideration a number of other important constituents which have been for the most part named after distinguished research metallurgists. Thus we have to consider such constituents as austenite, martensite, troostite, sorbite, and osmondite.

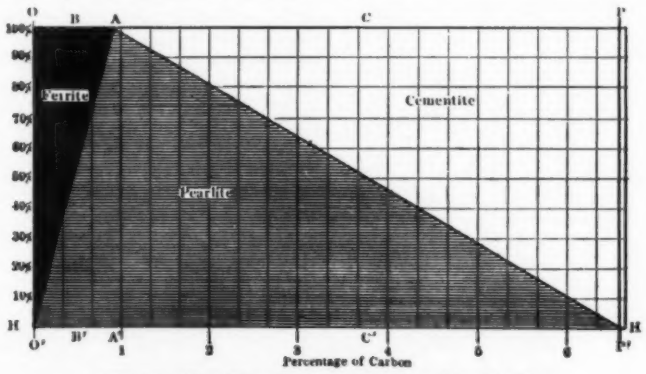


Fig. 4.—Constituents of annealed carbon steels.

In a general way it may be explained that some or all of these carbon-iron constituents are formed when steel which has been heated to some temperature above the critical point A_3, but below the melting point, is suddenly quenched in water or oil, and then perhaps slowly reheated or tempered. Such action is now known in a general way as "heat treatment." For instance, if a carbon steel containing about 1.5 per cent of carbon is heated to 1,100 deg. Cent. and then suddenly plunged into cold water, a so-called solid solution of iron carbide (cementite) in pure iron (ferrite) is suddenly locked or fixed in the structure of the steel. This is the austenite of modern metallurgical research. If such a metal is subsequently annealed by prolonged heating, the austenite breaks down again into the softer pearlitic structure. This is an important point, and should be borne in mind in order to make clear what we shall discuss later. Martensite is used to designate a transition from between austenite on the one hand and ferrite and cementite (pearlite) on the other, and is a varying combination of the three constituents. Trootsite, sorbite, and osmondite we need not take time here to define in detail. In general, they are terms used to designate transition forms between the constituents already described. Pure iron, of course, consists only of ferrite, and contains none of these various carbon constituents.

All this scientific nomenclature is of special interest to the immediate purpose of this paper only to the extent that it serves to illustrate what modern research has done, and is now doing, to explain and elucidate the extraordinary characteristics of iron and steel. The old-fashioned smith or artisan quenched and tempered his steels and was guided to his result by watching the characteristic colors imparted to his metal by the changes from one constituent to another. The modern metallurgist no longer trusts his eyes, but is guided along his path of development by the aid of the microscope and pyrometer. As a distinguished authority has stated:[3]

"For at least a thousand years, and probably for several thousand, there had been no single important advance, no one striking development, in the nature and characteristics of steel, in respect to metal-cutting qualities, at any rate. The property of becoming hard, possessed in common by all steels, and distinguishing them from ordinary iron, is due to the presence of carbon diffused throughout the mass of the metal. How the presence of the particles of carbon brings about the virtue of hardening is yet a matter of discussion.

"Modern steel making is a fact only because the science of chemistry, itself scarcely a century and a half old, has made it possible to understand that there is an affinity of certain elements for certain others, and that under given conditions exactly the same combinations can be expected in chemical compounds and alloys. The prehistoric steel makers had no idea that in firing iron with certain fuels they were carbonizing it, actually forming of the iron and fuel a new substance which contained besides iron the same element which in one form constitutes charcoal, in another graphite, and in a third diamond. That, however, is exactly what they did."

The salient fact which makes research work in the field of iron and steel metallurgy so fascinating and valuable is the rich possibilities involved in its exploitation. The writer imagines, without knowing from personal experience, that the fascination of the pursuit of the study of music to a real musician or composer must reside in the almost infinite possibilities which lie within combinations of harmonies and musical themes. To a very considerable extent the modern metallurgist is a composer who is playing on a combination of almost limitless possibilities. If there is any one reason more than another which proves this statement true, it depends upon these two facts: First, because either by an accident of nature or by design the two elements, iron and carbon, possess affinities which cause them to combine in a succession of almost harmonic possibilities; and, second, because iron also has the power of linking up or combining with or dissolving in itself nearly all of the other material elements in such a manner and with such a character that the most minute quantities of these elements or combinations of them produce differences in the resulting metal or alloy, of the most profound and important nature. Allow me to dwell briefly on this idea.

It is an interesting fact that out of the seventy to eighty elements which comprise, as it were, the building blocks of the material universe, only about twelve or fourteen are commonly used either by Nature or by man. All the others are what may be generally classed as rare elements, even the names of which sound strange and unfamiliar to the ears of men of ordinary education. These rare or rarer elements seem to comprise Nature's scrap-heap, into which scientific man is painstakingly digging and delving in the effort to gain something from it for his purpose. What the chemist and physicist has done with this scrap-heap is prominently before us in these days, for he has discovered and introduced to us such wonder elements as radium and thorium, and now he is finding a use for the extraordinary element selenium, which changes its electrical conductivity under the influence of light and other sources of radiant energy. I would not like to prophesy as to the wonders man may accomplish in the future, due to this unusual and unique property possessed by the element selenium. But to return to our subject, I wish to point out that the research metallurgist has not been idle in poking about in Nature's scrap-heap for elements to combine with iron, and thus increase the wonder-working properties of this already wonderful metal.

(*To be concluded.*)

Measurements of Radio-activity in Water

THE radioactivity of water and of the gases contained in water is measured by the effect produced on a charged electroscope by radium emanation (niton), a gas that is given off by radium-bearing minerals in proportion to their content of radium. The general opinion that most spring waters do not contain radium itself, but radium emanation derived from contact with radium-bearing minerals is logically based on the fact that nearly all spring waters gradually lose their radioactivity after being removed from the source, whereas a solution of a radium salt, after having once reached equilibrium, continues to give off radium emanation. The sample of water is boiled to drive off the emanation, which is dried and then swept by a current of air into an airtight electroscope. The latter instrument consists essentially of a jar from the cover of which is suspended a rod supporting at its lower extremity a metal strip and a leaf of aluminium foil. When the system is electrically charged the aluminium foil is deflected from its vertical position, to which it normally returns very slowly as the charge is dissipated. If, however, radium emanation is present in the jar the rate of leakage and consequently the rate of fall of the foil are greatly accelerated. The rate of leakage in the presence of the emanation from a measured quantity of water is therefore observed and compared with the rate of leakage similarly mensured on the emana-

[1] "Critical Ranges A_3 and A_4 of Pure Iron." G. K. Burgess and J. J. Crowe; Scientific Paper, U. S. Bureau of Standards 213, p. 316.

[2] "High Speed Steel"; Becker, p. 26.

[3] Becker, *loc. cit.*, p. 7.

tion from a solution of a weighed portion of a mineral whose content of radioactive substance has been determined. From these data the radioactivity of the sample of water can be calculated. The results of such measurements have unfortunately been expressed in a great variety of units, and as a natural consequence it is impossible to compare some reports of radioactivity with others. In England and America it is customary to express radioactivity as an equivalent of radium or of uranium, a radioactive substance; on the Continent it is customary to express the results in electrostatic units. It is quite general, irrespective of the unit, to report the radioactivity per liter of water or per liter of the gas in the water. The quantity of emanation in equilibrium with 1 gramme of radium is known as a curie of emanation, but as this is a very large unit estimates are expressed in fractional parts of a curie; thus, 22.9×10^{-9} curie per liter means that one liter of the water contains 229 ten-billionths of the quantity of emanation in equilibrium with 1 gramme of radium. The mache unit, frequently encountered in reports of radioactivity, is defined as the saturation ionization current due to the radium emanation, free from decay products, from a liter of water or gas, expressed in electrostatic units (*i*) multiplied by 1,000; and 1 curie of emanation per liter equals a concentration of 2,670 million mache units.—R. M. Dole in *Mineral Resources of the United States*, 1913. Part II: 24.

A Crew for Big Aircraft

THE Sikorsky biplane is significant of future developments. Hitherto the pilot while steering and controlling the aeroplane has also at the same time controlled the motor. But it is obvious that with a multiple power plant this is no longer possible, and accordingly on the Sikorsky the pilot operates the aeroplane controls proper, while an engineer is in charge of the motor controls, receiving his orders from the pilot. The growing necessity for some such division of labor has long been apparent in these days, when the length of flight has been increasing so rapidly, and the pilot, in addition to his other arduous duties, has had to undertake those of navigator. In time to come and for long journeys the control of the giant machines of the future will no doubt be still further subdivided. The pilot will confine his attention purely to the flying and steering of the aeroplane; an engineer will be in charge of the motors; while a navigating officer will map out the course and, if necessary, take the required observations, astronomical or otherwise.—*London Daily Telegraph*.

The Big Atlantic Liners

Some Details That Help to an Appreciation of Their Remarkable Proportions

THE pictures of the monster steamships that ply the Atlantic between the United States and Europe usually show the vessels as a whole in open water, and it is difficult for those without special means of judging to gain an adequate idea of their vast proportions; a few illustrations, therefore, of some of the individual parts, with figures and explanations, will furnish a better basis for comparison and a more thorough appreciation of the giant scale to which the floating cities have been built.

The illustrations used in this article show portions of the English steamer "Britannic," which was launched early in 1914, the principal dimensions of which are as follows:

Length over all	882 feet 6 inches
Breadth, extreme	93 feet 6 inches
Draft, loaded	34 feet 7 inches
Displacement	Over 53,000 tons
Sea speed	21 knots
Number of decks	9
Passenger accommodations:	
First class	790
Second class	836
Third class	953
	2,579
Crew	950
Total	3,529

The illustrations herewith shown were taken during the building of the vessel, and the first one, on the first page, shows one of the enormous funnels in process of being hoisted into place on the ship. This great chimney is 150 feet high above the furnace bars, and it will be noticed that it is not round but elliptical in cross-section, being 24 feet 3 inches in one diameter and 19 feet 10 inches in the other, big enough to drive two of the largest size trucks through abreast and fully loaded. There are four of these great stacks, and with each one about twenty uptakes are connected, some of which come from several furnaces, for these four funnels have to take care of the smoke and gases from 159 furnaces.

The ship is driven by three propellers, the two on the outside being operated by vertical triple-expansion, reciprocating engines of 16,000 horse-power each, while the center screw is connected with an immense low-pressure steam turbine that delivers 18,000 horse-power, making a total of 40,000 horse-power; and to supply these motors with the necessary steam for their operation requires the evaporation of 700,000 pounds of

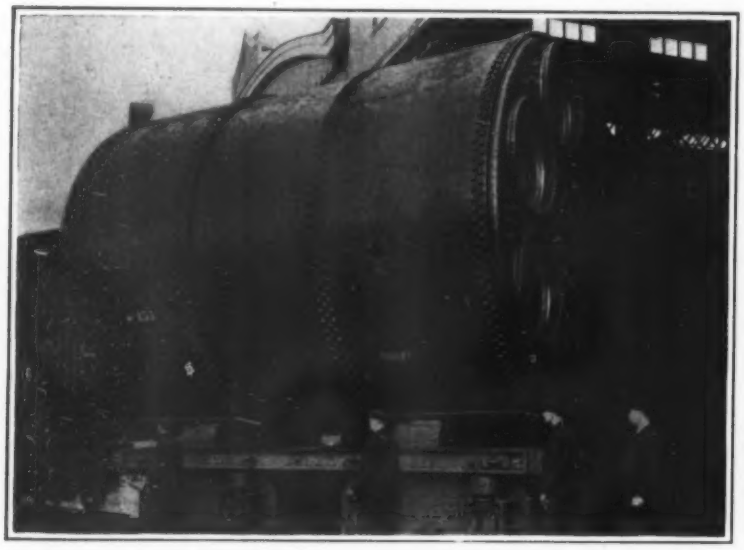


Fig. 2.—One of the twenty-nine boilers required to produce steam on a big ship.

Fig. 3.—The "rotor" of an 18,000 horse-power turbine.

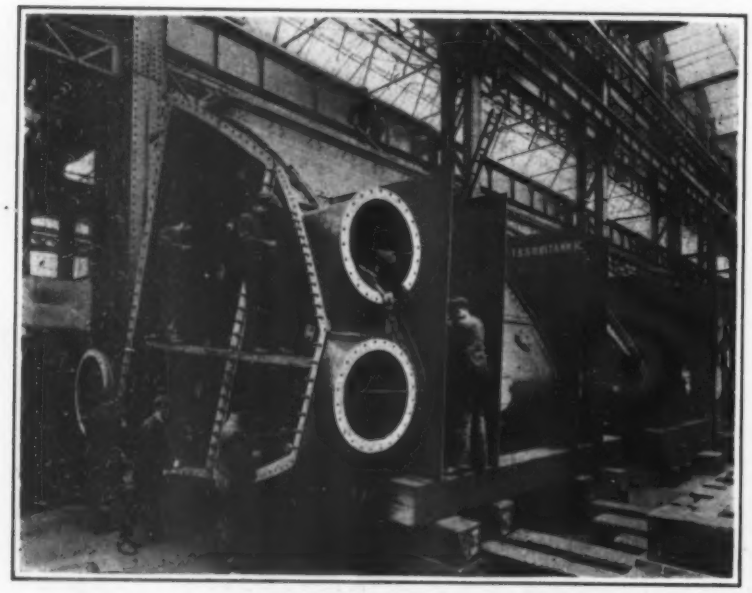


Fig. 4.—Making tight the tubes of one of the condensers.

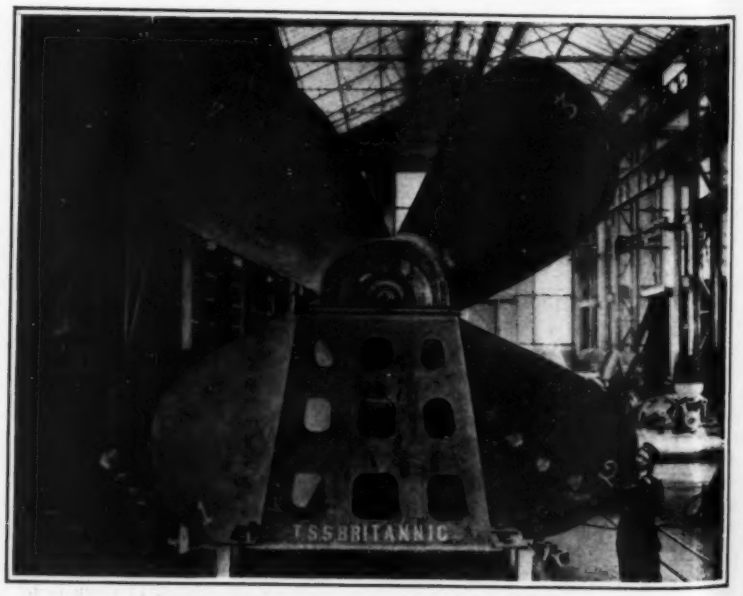


Fig. 5.—Balancing and smoothing a propeller wheel.

water every hour, or enough to supply a town of over 5,000 population for a whole day. To perform this work there are twenty-nine great boilers, five of which are what are called single boilers, and have furnaces in one end only, while the other twenty-four are double, and are provided with three capacious furnaces in each end. Fig. 2 shows one of these latter boilers, and its unusual size can be judged by comparison with the men standing by it. This boiler is 21 feet 10 inches long and 16 feet 5 inches in diameter, and is constructed with an outer shell of steel plates over an inch and one-half thick to withstand the working steam pressure of 215 pounds.

Fig. 3 gives some idea of the powerful propelling machinery, and shows the "rotor," or working part of the low-pressure turbine. This is a great cylinder, or drum, on the outer surface of which are fixed thousands of long narrow blades, set in regular rows around the body of the rotor, which is mounted on a shaft that is 3 feet in diameter in the bearings. The rotor is 12 feet 6 inches in diameter and 14 feet 11 inches long, and weighs about 150 tons complete; and it turns at 170 revolutions per minute when delivering its 18,000 horse-power. After the high-pressure steam has been used in the reciprocating engines it passes on to this big turbine, which it reaches at an actual pressure of 10 pounds, and after passing the rotor is exhausted in two condensers at about 28 inches vacuum when the barometer stands at 30 inches. As this low-pressure steam impinges on the blades of the rotor but a small amount of power is imparted to each one; but this insignificant increment multiplied by the thousands of blades, each of which adds its tiny mite, and also multiplied by the number of impulses that each contributes each minute, all foots up to the very substantial total mentioned above.

After the steam has performed its final task in the turbine it passes to the condenser, where it it reconverted into water, which is fed back into the boilers to again be made into steam. Salt water is not desirable for steam making, so fresh water is used entirely, and as it would be impossible to carry enough fresh water for a voyage if the steam is wasted, it becomes necessary to save the waste steam, and so recover the water. The condenser is a large vessel in which there are a large number of brass tubes extending between partition plates located near the ends of the condenser. The steam is passed through these tubes, while outside and around them pours a flood of cold sea water which is constantly renewed and circulated through the condenser by large pumps. In the condenser shown in the illustration, Fig. 4, which is lying on its side, there are 9,620 of the small brass tubes, which would form a length of 25 miles, and the two connections shown on the right are for the admission and escape of the cooling water.

Of the three propeller wheels, the center one, driven by the turbine, is the smallest, being but 16½ feet in diameter. The wheel, which is of solid manganese bronze and weighs 22 tons, is shown in Fig. 5, where it is mounted on a pair of smooth, straight edge rails for the purpose of testing its balance, and the men seen in the picture are engaged in the important task of smoothing and sharpening the edges of the blades, for a rough, thick edge needlessly consumes a great amount of power that is entirely wasted. The two wing propellers, which are driven by the two reciprocating engines, are each 23½ feet in diameter, and have bronze blades bolted to cast steel hubs.

The Anschütz Dead-Reckoner*

By Von Wolfgang Otto

In nautical language, a ship's reckoning denotes the position of the vessel at a given instant, which may be represented by a point marked on the chart. The reckoning is astronomical if it is computed from observations of the sun, moon, or stars, combined with the reading of the chronometer. It is terrestrial if it is derived from observations of lighthouses or other landmarks. When neither shore nor sky can be seen, as in cloudy weather far from land, the ship's position must be obtained by "dead reckoning," i. e., by drawing on the chart, from the last surely determined position, a line in the direction of the course subsequently followed, and of a length corresponding to the distance traveled in the interval, as deduced from the elapsed time and the readings of the log. Whenever the course is changed, the new course must be drawn from the end of the old one, with proper allowance for the drift caused by wind and current.

It is not difficult to obtain the ship's position by this graphical method so long as the vessel's course and speed remain nearly constant, as they usually do in the case of passenger steamers. With warships, which frequently vary their course and speed, the problem becomes very complex, and only an expert can estimate with any approach to accuracy the effects produced by the changes in speed and by the great arcs traversed in changing the course. Yet it is exceedingly important to know the exact position of the vessel at any instant, especially in time of war, so that (for example) a scout cruiser, on sighting the enemy's fleet, can immediately report its location to headquarters by wireless signals.

The problem is solved completely by the automatic dead-reckoner invented by Dr. Anschütz-Kaempfe. The readings of this instrument require correction only for the effects of wind and current. All other influences are continuously measured with great precision, and their effects are drawn on a sheet of paper to the scale of the chart, by purely mechanical means.

* Translation from *Umschau*.

Fig. 1.—Log and turbine of the Anschütz dead-reckoner.

It might be supposed that an apparatus capable of such a performance must be very complicated, but in reality the basic principle of its operation is quite simple, for all that is required is the product of two factors: the course and the speed of the vessel.

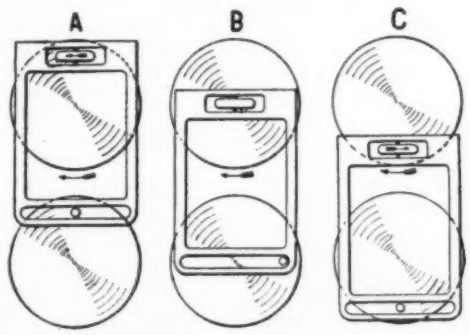


Fig. 2.

The speed is measured by a small turbine attached to the hull of the ship. The rotary movement of the turbine is transmitted to a disk. Each face of this disk touches the rim of a small wheel, the planes of the two wheels being perpendicular to the disk and to each other. The wheels are connected with the Anschütz gyrostatic compass by appropriate transmission mechanism in such a manner that the deflections of the compass cause them to move along mutually perpendicular diameters of the disk, parallel to their axes. In this way the velocity of the ship is resolved into a north or south, and an east or west, component. For example, if the vessel is moving due north, one of the wheels (shown at *A*, Fig. 2) is at the edge of the disk and is consequently rotating with the greatest rapidity it can have with the given velocity of the disk, which is proportional to the momentary speed of the vessel. In the same conditions the other wheel (at the back of the disk and not shown in the diagram) is at the center of the disk and is not rotating. When the course is due east or west the north-and-south wheel is motionless at the center (*B*, Fig. 2), while the east-and-west wheel is at the edge and is taking up the whole motion of the disk. When the course is due south the north-and-south wheel is at *C* and rotating in a direction opposite to that of its rotation at *A*. In any other course of the vessel (NE, SSW, etc.) each wheel is in a position intermediate between the center and the rim of the disk and is rotating with a velocity proportional to the north-and-south (or the east-and-west) component of the vessel's speed. Each wheel reverses its rotation as it passes the center of the disk and each is connected with counting mechanism, which works both ways. Hence, the progress of the vessel to north or south and to east or west can be read directly from the dials.

The two components are recombined in the graphical recorder of the apparatus, in which the pencil is moved horizontally by one component and vertically by the other. The drawing, therefore, gives a complete picture of the evolutions of the ship.

The first practicable apparatus of this kind has been in continual use for more than two years on the battleship "Moltke" and has proved eminently successful. Experiments had previously been made with many similar devices, but all of these lacked the most important feature, the gyrostatic compass, which is free from the defects and irregularities of the magnetic compass and is also able to exert and transmit great mechanical force.

Therapeutic Uses of Radioactive Waters

Radioactive waters are applied to the body in practically every manner that mineral waters have heretofore been used; baths, douches, and local applications of every description are employed, and the waters are also drunk and injected. In addition to these methods of administration, rooms or closets, called inhalatoria and emanatoria, are so arranged that patients may breathe the radium emanation in the gases that escape from the waters. The more completely equipped watering places have arrangements for combination of radium treatment with electric, muscular, aqueous, and other kinds of massage, hot-air baths, mud baths, and X-ray and violet-ray treatment. At some sanatoriums these treatments are given by means of waters, muds, packings, and compresses that have been rendered artificially radioactive. A great variety of diseases are treated, among which may be mentioned especially croupous pneumonia, bronchitis, bronchial asthma, articular rheumatism, tuberculosis, syphilis, gout, diabetes, and obesity. In reference to the physiologic reactions following treatment by the radioactive waters of Bath, Atkins, and Harrison are quoted by Low (Lancet, April 20th, 1912) as saying that radium increases diuresis, excretion of uric acid, and exhalation of carbon dioxide; lowers the pressure of the blood and decreases its viscosity; increases the rate of decomposition of uric acid; inhibits inflammation; increases sexual vitality; and has considerable influence over sympathetic affections. As a concluding comment on this topic, it is well to repeat that there is much conflicting testimony on the therapeutic value of radioactive waters and that the physiologic effects of relatively strong solutions of radium salts may not necessarily be duplicated by weakly radioactive natural waters.—R. B. Dole in *Mineral Resources of the United States*, 1913. Part II: 24.

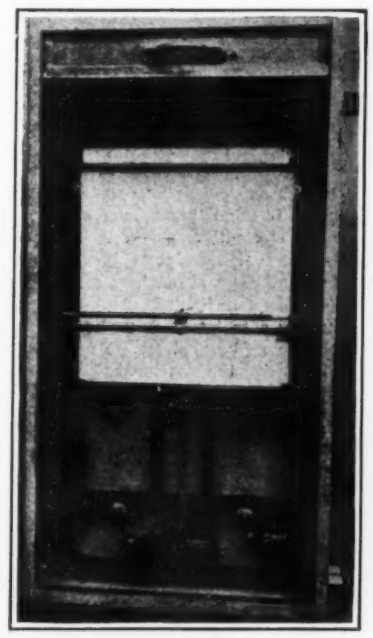


Fig. 3.—The graphic recorder.

Man as a Geographical Agency

The New Geography to be the Record of Changes Made by Man

In his presidential address before the Geographical Section of the British Association for the Advancement of Science in Australia, Sir Charles P. Lucas reminded his hearers that the earth is now quite well known from pole to pole, and that, although there remains some work to be done in clearing up the details of a few corners, discovery pure and simple is passing away. But he calls attention to a statement of Sir Clement Markham, formerly president of the Royal Geographical Society, that "Geography is a description of the earth as it is in relation to man," and makes the point that, in view of the rapidly increasing changes that are being made by man, changes that not only alter the outlines, but the character and climate of the earth's surface, geography in the future will be rather a record of the changes which successive generations of man have made and are making in the earth. In developing his ideas of the new geography the speaker had the following to say.

The writer who used this phrase, "Man is a geographical agency," the American writer, Mr. G. P. Marsh, published his book, "Man and Nature," in 1864, and a new edition, entitled "The Earth as Modified by Human Action," in 1874. He was mainly concerned with the destructiveness of man in the geographical and climatic changes which he has effected. "Every plant, every animal," he writes, "is a geographical agency; man a destructive, vegetables, and in some cases even wild beasts, restorative powers"; and again: "It is in general true that the intervention of man has hitherto seemed to insure the final exhaustion, ruin, and desolation of every province of nature which he has reduced to his dominion." The more civilized man has become, he tells us, the more he has destroyed.

He took this gloomy view mainly on account of the mischief done by cutting down forests. Man has wrought this destruction not only with his own hand, but through domesticated animals more destructive than wild beasts, sheep, goats, horned cattle, stunting or killing the young shoots of trees. "Man," he says, "has too long forgotten that the earth was given to him for usufruct alone, not for consumption, still less for profligate waste."

The damage done by cutting down trees, and thereby letting loose torrents which wash away the soil, is or was very marked in the south of France, in Dauphiné, Provence, and the French Alps. With the felling of trees and the pasturing of sheep on the upper edge of the forest—for sheep break the soil and expose the roots—the higher ground has been laid bare. Rainstorms have in consequence swept off the soil, and the floods have devastated the valleys. The mountain sides have become deserts, and the valleys have been turned into swamps. "When they destroyed the forest," wrote the great French geographer, Reclus, about thirty years ago, "they also destroyed the very ground on which it stood"; and then he continues: "The devastating action of the streams in the French Alps is a very curious phenomenon in the historical point of view, for it explains why so many of the districts of Syria, Greece, Asia Minor, Africa, and Spain have been forsaken by their inhabitants. The men have disappeared along with the trees; the axe of the woodman, no less than the sword of the conqueror, have put an end to, or transplanted, entire populations."

How far has the agency of man altered, and how far is it likely to alter, the surface of the earth, the divisions and boundaries assigned by nature, the climate, and the production of the different parts of the globe; and, further, how far, when not actually transforming nature, is human agency giving nature the go-by? It should be borne in mind that science has effected, and is effecting transformation, partly by applying to old processes far more powerful machinery, partly by introducing new processes altogether; and that, as each new force is brought to light, lands and peoples are to a greater or less extent transformed. The world was laid out afresh by coal and steam. A new readjustment is taking place with the development of water power and oil power. Lands with no coal, but with fine water power or access to oil, are asserting themselves. Oil fuel is prolonging continuous voyages and making coaling stations superfluous. But of necessity it is the earth herself who gives the machinery for altering her own surface. The application of the machinery is contributed by the wit of man.

The surface of the earth consists of land and water. How far has human agency converted water into land or land into water, and how far, without actually transforming land into water and water into land, is it for practical human purposes altering the meaning of land and water as the great geographical divisions? A writer on the Fens of South Lincolnshire has told us: "The Romans, not content with appropriating land all over the world, added to their territory at home by draining lakes and reclaiming marshes." We can instance another great race which, while appropriating land all over the world, has added to it by reclaiming land from water, fresh or salt. Now the amount of land taken from water by man has been taken more from fresh water than from sea, and, taken in all, the amount is infinitesimal as compared with the total area of land and water; but it has been very considerable in certain small areas of the earth's surface, and from these small areas have come races of men who have profoundly modified the geography and history of the world. This may be illustrated from the Netherlands and from Great Britain. The crowning vision of Goethe's Faust is that of a free people on a free soil, won from the sea and kept for human habitation by the daily effort of man. Such has been the story of the Netherlands. Instances of reclaiming land might be indefinitely multiplied.

How far has land been drowned by the agency of man? Again the total area is a negligible quantity, but again, relatively to small areas, it has been appreciable, and the indirect effects have been great. The necessities of town life are responsible for new lakes and rivers. Such are the great reservoirs and aqueducts by which water is being brought to New York from the Catskill Mountains, a work which a writer in the *Times* has described as "hardly second in magnitude and importance to the Panama Canal." A still larger volume of water is gathered by the great Assouan dam, which holds up the Nile at the head of the First Cataract, washing, and at times submerging, the old temples on the Island of Philæ in mid-stream. Take again the great ship canals. The Suez Canal runs for 100 miles from sea to sea, though for part of its course it runs through water, not through sand. It is constantly growing in depth and width. A writer in the *Times* on the wonderful Panama Canal said: "The locks and the Gatun dam have entailed a far larger displacement of the earth's surface than has ever been attempted by the hand of man in so limited a space." The canal is only fifty miles long from open sea to open sea, from shore line to shore line only forty. But in making it man, the geographical agency, has blocked the waters of a river, the Chagres, by building up a ridge which connects the two lines of hills between which the river flows, with the result that a lake has come into existence which is three quarters of the size of the Lake of Geneva.

Mr. Marsh, in his book, referred to far more colossal schemes for turning land into water, such as flooding the African Sahara or cutting a canal from the Mediterranean to the Jordan and thus submerging the basin of the Dead Sea, which is below the level of the ocean. All that can be said is that the wild-cat schemes of one century often become the domesticated possibilities of the next and the accomplished facts of the third; that the more discovery of new lands passes out of sight the more men's energies and imagination will be concentrated upon developing and altering what is in their keeping; and that, judging from the past, no unscientific man can safely set any limit whatever to the future achievements of science.

But now, given that the proportion of land to water and water to land has not been, and assuming that it will not be, appreciably altered, has water, for practical purposes, encroached on land, or land on water? In many cases water transport has encroached on land transport. The great isthmus canals are an obvious instance; so are the great Canadian canals. Waterways are made where there was dry land, and more often existing inland waterways are converted into seagoing ways. Manchester has become a seaport through its ship canal. The Clyde has been "converted from an insignificant stream into a deep navigable river." It is because engineers have artificially improved nature's work on the Clyde and the Tyne that these rivers have become homes of shipbuilding for the whole world. Building training walls on the Seine placed Rouen, seventy-eight miles up the river, high among the seaports of France. The Elbe and the Rhine, the giant rivers Mississippi and St. Lawrence, and many other rivers, have, as we all know, been wonderfully transformed by the hand of the engineer.

But land in turn, in this matter of transport, has encroached upon sea. In old days, when roads were few and bad, when there were no railways, and when ships were small, it was all-important to bring goods by water at all parts as far inland as possible. In England there were numerous flourishing little ports in all the estuaries and up the rivers, which, under modern conditions, have decayed. No one now thinks of Canterbury and Winchester in connection with seaborne traffic; but Mr. Belloc, in "The Old Road," points out how these two old-world cathedral cities took their origin and derived their importance from the fact that each of them, Canterbury in particular, was within easy reach of the coast, where a crossing from France would be made; each on a river. In the days when the Island of Thanet was really an island, separated from the rest of Kent by an arm of the sea, and when the present insignificant river Stour was a wide and navigable estuary, Canterbury was a focus to which the merchandise of six Kentish seaports was brought, to pass on inland; it was in effect practically a seaport. Now merchandise comes to a few large ports only, and is carried direct by rail to great distant inland centers. Reclus wrote that bays are constantly losing in comparative importance as the inland ways of rapid communication increase; that, in all countries intersected with railways, indentations in the coast-line have become rather an obstacle than an advantage; and that maritime commerce tends more and more to take for its starting place ports situated at the end of a peninsula. He argues, in short, that traffic goes on land as far out to sea as possible instead of being brought by water as far inland as possible. He clearly overstated the case, but my contention is that, for human purposes, the coast-line, though the same on the map, has practically been altered by human agency. Ports have been brought to men as much as men to ports.

But let us carry the argument a little further. Great Britain is an island. Unless there is some great convulsion of nature, to all time the Straits of Dover will separate it from the continent of Europe. Yet we have at this moment a renewal of the scheme for a Channel tunnel, and at this moment men are flying from England to France and France to England. Suppose the Channel tunnel to be made; suppose flying to be improved—and it is improving every day—what will become of the island? What will become of the sea? They will be there and will be shown on the map, but to all human intents and purposes the geography will be changed. The sea will no longer be a barrier, it will no longer be the only high-road from England to France.

Men think in years, or at most in lifetimes; they ought sometimes to think in centuries. I believe in Reclus's words, "All man has hitherto done is a trifle in comparison with what he will be able to effect in future." Science is like a woman. She says No again and again, but means Yes in the end.

In dealing with land and water I have touched upon natural divisions and natural boundaries, which are one of the provinces of geography. Flying gives the go-by to all natural divisions and boundaries, even the sea; but let us come down to the earth. Isthmuses are natural divisions between seas; the ship canals cut them and link the seas—the canal through the Isthmus of Corinth, the canal which cuts the Isthmus of Perekop between the Crimea and the mainland of Russia, the Baltic Canal, the Suez Canal, the Panama Canal. Inland, what are natural divisions? Mountains, forests, deserts, and, to some extent, rivers. Take mountains. "High, massive mountain systems," writes Miss Semple, "present the most effective barriers which man meets on the land surface of the earth." But are the Rocky Mountains, for instance, boundaries, dividing-lines, to anything like the extent that they were now that railways go through and over them, carrying hundreds of human beings back and fore day by day? On what terms did British Columbia join the Dominion of Canada? That the natural barrier between them should be pierced by the railway.

If, in the Bible language, it requires faith to remove mountains, it is not wholly so with other natural boundaries. Forests were, in old days, very real natural dividing-lines. They were so in England, as in our own day they have been in Central Africa. Between forty and fifty years ago, in his "Historical Maps of England," Prof. C. H. Pearson, laid down that England was settled from east and west, because over against Gaul were heavy woods, greater barriers than the sea. Kent was cut off from Central England by the Andred Weald, said to have been, in King Alfred's time, 120 miles long and 30 broad. Here are Prof. Pearson's words: "The axe of the woodman clearing away the forests, the labor of nameless generations reclaiming the fringes of the fens or making their islands habitable, have gradually transformed England into one country, inhabited by one people.

Can the same be said of deserts? They can certainly be pierced, like isthmuses and like mountains. The Australian desert is a natural division between Western and South Australia. The desert will be there, at any rate for many a long day after the transcontinental railway has been finished, but will it be, in anything like the same sense as before, a barrier placed by nature and respected by man? As we all know, if population is available, they bring in their train development of the land through which they pass. Are these deserts of the earth always going to remain "deserts idle"? Is man going to obliterate them? In the days to come, will the desert rejoice and blossom as the rose? What will dry farming and what will afforestation have to say? A book has lately been published entitled "The Conquest of the Desert." The writer, Dr. Macdonald, deals with the Kalahari Desert in South Africa, and for the conquest of the desert he lays down that three things are essential—population, conservation, and afforestation. He points out in words which might have been embodied in Mr. Marsh's book, how the desert zone has advanced through the reckless cutting of trees, and how it can be flung back again by tree barriers to the sand dunes. By conservation he means the system of dry farming so successful in the United States of America, which preserves the moisture in the soil and makes the desert produce fine crops of durum wheat without a drop of rain falling upon it from seedtime to harvest. If the settlers come, he holds that the agency of man, tree-planting, ploughing, and harrowing the soil, will drive back and kill out the desert.

What, again, will irrigation have to say to the deserts? Irrigation has already changed the face of the earth, and as the years go on, as knowledge grows and wisdom, must inevitably change it more and more. I read of underground waters in the Kalahari. I read of them too in the Libyan Desert. In the "Geographical Journal" for 1902 it is stated that at that date nearly 22,000 square miles in the Algerian Sahara had been reclaimed with water from artesian wells. What artesian and sub-artesian water has done for Australia you all know. If it is not so much available for agricultural purposes, it has enabled flocks and herds to live and thrive in what would be otherwise arid areas.

Thus I have given you four kinds of barriers or divisions set by nature upon the face of the earth—mountains, forests, deserts, rivers. The first, the mountains, man cannot remove, but he can and he does go through them to save the trouble and difficulty of going over them. The second, the forests, he has largely cleared away altogether. The third, the deserts, he is beginning to treat like the forests. The fourth, the rivers, he is beginning to shift when it suits his purpose and to regulate their flow at will.

I turn to climate. Climates are hot or cold, wet or dry, healthy or unhealthy. Here our old friends the trees have much to say. Climates beyond dispute become at once hotter and colder when trees have been cut down and the face of the earth has been laid bare; they become dryer and moister according as trees are destroyed or trees are planted and hold the moisture; the cutting and planting of timber affects either one way or the other the health of a district. The tilling of the soil modifies the climate.

Nowhere have the triumphs of medical science been more conspicuous than where engineers have performed their greatest feats. De Lesseps decided that Ismailia should be the headquarters of the Suez Canal, but the prevalence of malaria made it necessary to transfer the headquarters to Port Said. In 1886 there were 2,300 cases of malaria at Ismailia; in 1900 almost exactly the same number. In 1901 Sir Ronald Ross was called in to advise; in 1906 there were no fresh cases, and malaria has been stamped out. Lesseps' attempt to construct the Panama Canal was defeated largely, if not mainly, by the frightful death-rate among the laborers; 50,000 lives are said to have been lost, the result of malaria and yellow fever. When the Americans took up the enterprise they started with sending in doctors and sanitary experts, and the result, of splendid medical skill and sanitary administration was that malaria and yellow fever were practically killed out. Man is a geographical agency, and in no respect more than in the effect of his handiwork on climate, for climate determines products, human and others. Science is deciding that animal pests shall be extirpated in the tropics, and that there shall be no climates which shall be barred to white men on the ground of danger of infection from tropical diseases.

If we turn to products, it is almost superfluous to give illustrations of the changes wrought by man. As the incoming white man has in many places supplanted the colored aboriginal, so the plants and the living creatures brought in by the white man have in many cases, as you know well, ousted the flora and fauna of the soil.

Australia is the same island continent that it always was; there are the same indentations of coast, the same mountains and rivers, but the face of the land is different. In past years there was no town, and the country was wilderness; on the surface of the wilderness many of the living things were different; and from under the earth has come water and mineral, the existence of which was not suspected. A century hence it will be different again, and I want to see sets of maps illustrating more clearly than is now the case the changes which successive generations of men have made and are making in the face of Australia and of the whole earth.

More than half a century ago Buckle, in his "History of Civilization," wrote: "Formerly the richest countries were those in which nature was most bountiful; now the richest countries are those in which man is most active. For in our age of the world, if nature is parsimonious we know how to compensate her deficiencies. If a river is difficult to navigate, or a country difficult to traverse, an engineer can correct the error and remedy the evil. If we have no rivers we make canals; if we have no natural harbors we make artificial ones."

An island continent Australia is still, and always will be, on the maps. It always will be the same number of miles distant from other lands; but will these maps represent practical everyday facts? What do miles mean when it takes a perpetually diminishing time to cover them? Is it not truer to facts to measure distances, as do Swiss guides, in Stunden (hours)? What, once more, will an island continent mean if the sea is to be overlooked and overflown? The tendency is for the world to become one; and we know perfectly well that, as far as distance is concerned, for practical purposes the geographical position of Australia has changed through the agency of scientific man. If you come to think of it, what geography has been more concerned with than anything else, directly or indirectly, is distance. It is the knowledge of other places not at our actual door that we teach in geography, how to get there, what to find when we get there, and so forth. Year after year, because distance is being diminished, coming and going of men and of products is multiplying; steadily and surely the world is becoming one continent. This is what I want geographers to note and the peoples to learn. Geographers have recorded what the world is according to nature. I want them to note and teach others to note how under an all-wise Providence it is being subdued, replenished, recast, and contracted by man.

Treatment of the Wounded

At the meeting of the Academy of Sciences, held in Paris on Monday, August 10th, a paper, of particular interest at the present time, was read by Inspector General Edmond Delorme dealing with the treatment of the wounded in modern warfare.[1] General Delorme became a surgeon in the French army during the last Franco-Prussian War, and has devoted his life to the advancement of military surgery, his text-book on that subject being recognized everywhere as a standard work. His opinion of the wounds inflicted by modern weapons is by no means pessimistic:

"The military surgeons, at the present time," he writes, "must adopt the most conservative methods of treatment in the great majority of military wounds; indeed, such methods must be applied in practically every case of bullet wound. The opening of a modern bullet wound is so small that if the surgeon adopts strict antiseptic or aseptic dressings and refrains from probing the wound or making a systematic search for foreign bodies arrested in its track, it is possible to give the most favorable prognosis for wounds of this class. Thanks to aseptic and antiseptic methods of treatment, the wounded run less risk than in former times."

The pointed bullet, employed by the German army, leaves very narrow wounds of entrance and exit when it penetrates the more fleshy parts of the body, but its track in the tissues themselves is marked by a considerable degree of destruction. Still, such cases, in General Delorme's opinion, should recover in the course of several days or perhaps weeks. On the other hand, wounds from shrapnel, or from deformed bullets, are often extensive, open, and complicated by the intrusion of clothing or other foreign bodies. Such wounds are not necessarily dangerous, but they frequently suppurate and require close attention when the wounded are being transported to the hospital at the base.

One naturally pays the closest attention to what General Delorme has to say regarding wounds of the abdomen—so fatal in former wars. During the last twenty years surgeons have so improved their technique that they now perform abdominal operations as safely as those on the limbs.

"The treatment of wounds of the abdomen," writes General Delorme, "deserves the closest attention of surgeons, particularly of those working at the front. We have new methods at our disposal which may ameliorate the results of a class of cases always regarded as of grave import. The advisability of operating on such cases in civil practice is open to discussion, but the case in war is quite different. In war the surgeons must lay aside any idea of opening the abdomen. The experience of all recent war is against such means—experience in the Transvaal, Manchuria, the Balkans. In the Transvaal, even when abdominal operations were carried out by the most eminent surgeons, under the best conditions, it was found that those who were operated on yielded a smaller percentage of recoveries than the cases which were not subjected to operation."

The modern German bullet, in full flight, leaves a very small wound on the wall of the abdomen, and seldom infects the wound by carrying clothing in front of it. The perforations produced by such bullets in the loops of intestine are minute and tend to close spontaneously. In some cases the bullet may pass between loops, leaving the intestinal wall intact.

The natural and salutary inclination on the part of the wounded to relieve both bladder and bowels, allowing the patient rest for some time, instead of hurrying him to the transport, allows a natural exudate to form round the wounded parts and favors the process of healing. For wounds of this kind the ancient methods of treatment seem best: absolute repose, refraining from prolonged transport, total abstinence from food and drink for several days, rinsing of the mouth, hypodermic injections of artificial serum, the administration of opium, and placing the patient in a half-sitting (Fowler's) posture.

It will be thus seen that the leading military surgeon of France advises conservative methods of treatment. We do not doubt that he is right. During an extensive action the surgeons at the front are suddenly overwhelmed by thousands of patients. It would be impossible to undertake, even were it advisable, prolonged, and tedious operations—to give attention to one case and neglect the remaining ninety-nine. Fortunately, at least in General Delorme's opinion, such operations at the front are unnecessary; the surgeon's business is simply to see that the wounded are placed in the best circumstances to allow their natural recuperative powers to have the best chance of exerting themselves.

Much of the paper to which we have directed attention is of a purely technical nature and directly concerns only surgeons of the navy and army. But much of it concerns us all, and we are glad to think that as our arms of precision have improved our methods of treating the injuries produced by such improvements have not lagged behind.—*Nature.*

[1] "Blessures de Guerre, Conseils aux Chirurgiens." Par M. Edmond Delorme. *Comptes rendus*, August 10, p. 394.

New Engineering Laboratories

The new engineering laboratories of the Dundee University College are among the best equipped in the United Kingdom. This department has been erected at a cost, including equipment, of $75,000. The main building of two stories contains lecture rooms, drawing offices, library, hydraulic laboratory, etc. An architectural feature is provided by the central tower, some eighty feet high, which houses the fan and machinery for forced ventilation of the building, and also contains a storage tank of 10,000 gallons for the piping of the hydraulic laboratory. Other quarters contain the heat-engine laboratory and boiler house, the strength of materials laboratory, cement testing room, and workshop. The heat engine room has an experimental steam engine, a gas engine and a gasoline motor, provision being made for a Diesel engine and a steam turbine. The steam engine is specially designed for experimental work and is of the horizontal compound type working with an electrically driven Worthington surface condensing plant, power being measured by an Appold brake. Speed can vary between 70 and 140 revolutions per minute, and about 100 horse-power is developed at 100 revolutions per minute with 250 pounds pressure. The National gas engine is of 30 horse-power and uses a suction producer, or city gas. Arrangements are made for measuring the amount and the heating value of fuel used, solid or gaseous. Gasoline motor is a 14-16 horse-power Argyll motorcar engine mounted stationary, power being absorbed by Prony brake or by an electric brake. Heat engine room has all the apparatus needed for measuring heat values of solid and gaseous fuels, also analysis of flue, exhaust and fuel gases, measurement of dryness of steam and the like. Steam comes from a Babcock-Wilcox boiler, with electric feed pump.

Some Recently Discovered Nubian Antiquities*

From a Garrison Which Held the Northern Sudan in the Hyksos Period, About 1700 B. C.

It might appear from an inspection of the statues and reliefs sent to the Museum of Fine Arts that the search for works of art was the only object of the Egyptian Expedition; and yet, however important these things are from the museum point of view, they can never be the sole object of an expedition which represents Harvard University as well as the Museum of Fine Arts. They are a partial product of field work aiming also at historical research. Long experience teaches that in the end the most methodical scientific work brings the best results, both artistic "finds" and historical conclusions. The great element of chance lies in the selection of a site. Once that is determined there is only one thing to do—extract all the information there is in the site, including necessarily all the antiquities.

The trip to the Sudan illustrates very clearly the practice of the expedition. Considering the possibilities of various sites, I came to the conclusion that the Nile Valley from Halfa to Merowe, held as Egyptian territory since the Middle Empire, might offer a profitable field of work. Egyptian fortresses and temples were known, royal statutes and decrees had been found in numbers. Another consideration of prime importance was the possibility of solving some of the questions raised by the Nubian Archæological Survey. During the survey a race and a civilization had been revealed, called by me the Nubian C-group, the date of which was fixed to the period between the Old and the New Empire, the very period for which we now needed museum material.

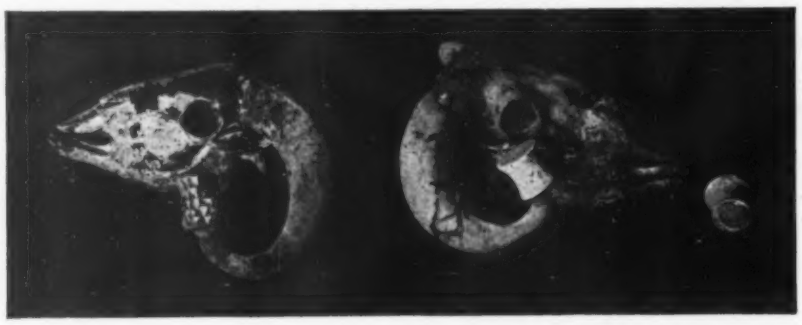
Casually mentioning my plans to Dr. Wreszinski of Königsberg, my attention was directed by him to Lepsius's notes on Nubia, just going through the press under Wreszinski's editorship. Lepsius had visited Kerma on June 20th, 1844, and had formed a great opinion of the place as an Old Empire site. This did not impress me; but he described at one place some rings of stones. These immediately attracted my attention, as such rings are characteristic of the graves of the Nubian C-group. I therefore resolved to include Kerma in the district to be visited. Nevertheless another site was selected for the chief point of examination, and this was Sêsi, opposite Delgo, which Prof. Breasted identified in 1907 with Gem-Atom, the southern capital of Amenophis IV (Dynasty XVIII).

Permission was kindly given by the Sudan government for the proposed survey, and on February 8th I arrived with thirty Egyptian workmen at Merowe, the capital of Dongola Province, on my way to Sêsi (see map of Nubia).

By the time we reached Argo, the last station before Kerma, I had made up my mind that it was my duty to stop at Kerma long enough to make a thorough examination, and I telegraphed to Khartum for the necessary permission, which was promptly granted.

Then came one of those romantic experiences which sometimes fall to the lot of the excavator—a grinding period of seemingly hopeless drudgery, a painful reconstruction of the history of the place from broken bits of things, and suddenly, quite at the end, a revelation of the civilization of the garrison of the Hyksos Period in a bewildering succession of "finds" incredibly preserved. In a few days customs were shown to us such as were never known before in this period, a race was found whose possible identification one hardly dared confess to one's self, and objects were piled up in the storerooms such as I had never hoped to see. There were wooden beds with latticed thong covering and legs carved to imitate bulls' legs (some of the legs cased in beaten gold), ostrich feather fans which could still be swung in the hand, swords with ivory and tortoise-shell handles, scarabs of the Hyksos Period, a mass of brilliant black and red polished pottery as thin and fine as good porcelain.

On the first morning I rode a donkey over the plain at Kerma on my preliminary inspection. I had spent the night in the irrigation rest-house, which was kindly placed at my disposal by Inspector Gurney. From the house I could see a great mud ruin a few miles to the south, called by the natives the Western or Lower Defûfa. As I rode toward it the Eastern or Upper

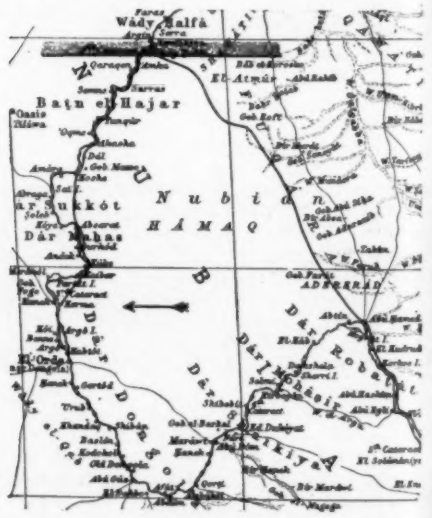


Heads of rams with horn protectors to prevent goring. From the cemetery.

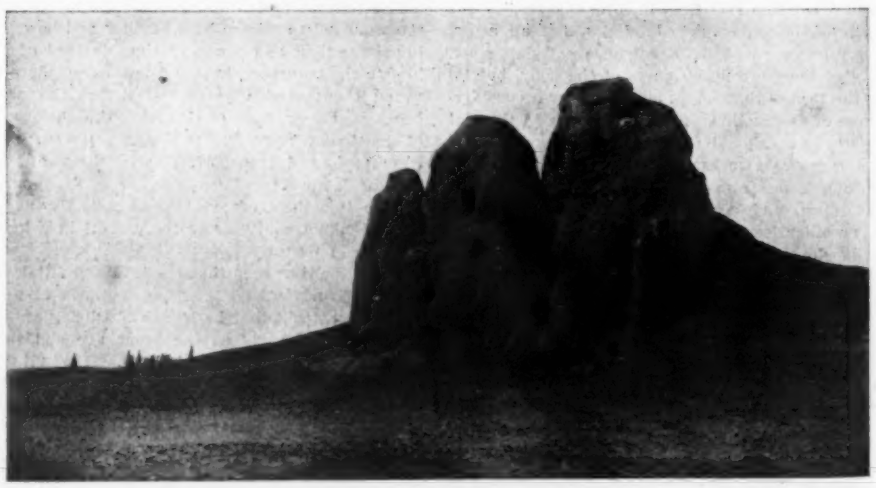
Grave, Kerma, 1065, chief burial intact on bed with sword between his legs, looking south.

Mica ornaments sewed on caps and dresses. From the cemetery of the Hyksos period.

Bust of black granite statuette of a king of the XII dynasty, probably Amen-em-hat III.



Map of Nubia.



Western Defûfa seen from the south.

* By courtesy of the Boston Museum of Fine Arts.

Defûfa came into view about five miles to the east. Everything appeared much as Lepsius had seen it on the 20th day of June nearly seventy years ago. The ground was strewn thickly with potsherds, stone implements, and fragments of bone; the mount of potsherds was there, the granite altar—all but the dike along the Nile. This was the western side of the basin. The middle was already green crop-land, irrigated at the last inundation; and the part I was riding over was that most threatened by the next inundation. Our work was clearly marked out for us. The first thing was to examine the Western Defûfa and "the plain of potsherds."

A number of potsherds and other objects were picked up on the surface, and the object register was started with these. Most of the potsherds appeared to be Nubian C-group. Four trenches were begun immediately round about the Defûfa "to determine the character of the *débris* and the presence or absence of graves." All but one of these trenches showed the layer of surface potsherds and other fragments to be about 40 to 100 centimeters thick, resting on a sub-soil of Nile mud, and with no trace of graves or structures. But in Trench 2 we came on a maze of burnt brick walls, and among them a fragment of an inscribed alabaster cup with the name of Pepy I, the king under whom was born the Impy whose unplundered tomb we had just found at Giza.

A series of walls were excavated on the west side, showing foundations of four periods of occupation. Fragments of inscribed alabaster gave us the names of Nefer-ka-Ra, Pepy I, Amenemhat I, and Sesostris I, proving that the place was occupied from the begin-

Bone and ivory inlay pieces, decorations from wooden furniture.

Ostrich feather fans from the great cemetery of the Hyksos period.

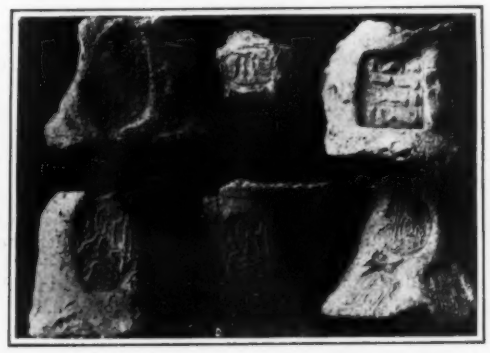
Stela of black granite dated in the thirty-third year of Amen-en-hat III (1816 B. C.), giving the ancient name of Kerma.

Nine scarabs and a golden crocodile from the great cemetery. Minute cup of blue paste with name of Sesostris I, from western Defûfa.

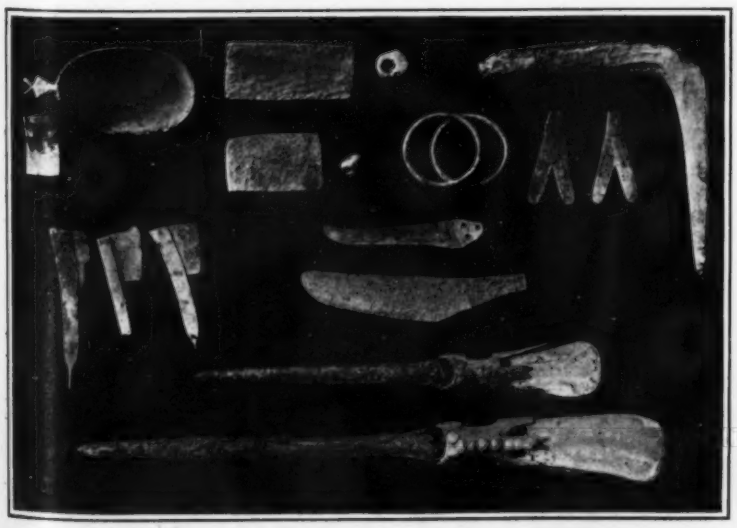
Beaten gold cases that covered the wooden bed legs, and a gold necklet with a single red carnelian bead.

Chair legs and bed legs of wood, raw hide sandals and head rest from cemetery.

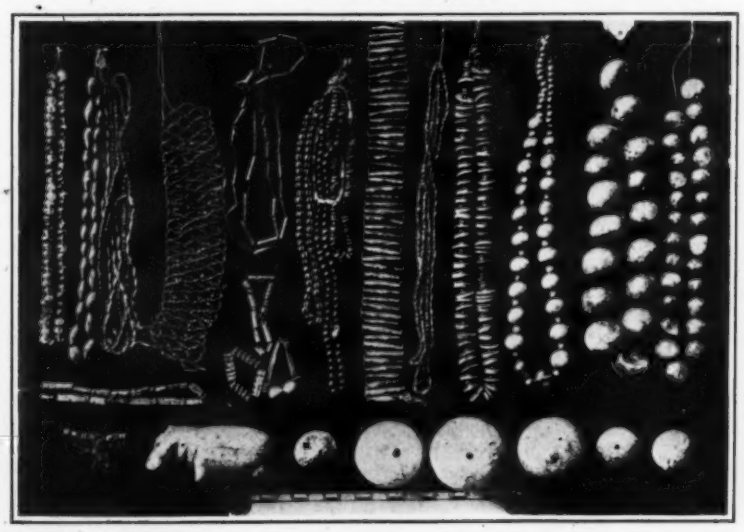
Pottery from rooms of western Defûfa.



Mud seal-impressions from the western Defûfa.



Wooden dish, kohl-palettes and bronze objects. The flies are military decorations. The hatchet-shaped tools were used as razors. The daggers have finely carved ivory and tortoise shell hilts and bronze blades. From the great cemetery.



Beads and amulets, arranged in the following order: Green glazed rock crystal, blue faience, bracelet of blue faience, blue faience, carnelian, beryl and blue faience, girdle of blue faience, two specimens of blue faience, blue faience, and two amethyst beads, two specimens of blue glazed quartz.

ning of the VI to the XII Dynasty. We followed the outline of the Defûfa around its four sides, but it was a solid mass like the under part of a fortress. On the east there was a series of rooms filled with the ashes and coals of a great conflagration, and on the floor were pots and pans, bone implements, pieces of ostrich eggs, over a thousand seal-impressions in mud, and many other remains of the last occupation—that which ended in fire. The seal-impressions fixed the date to the Hyksos Period.

Round about the Defûfa were heaps of ashes, slag, unfinished faiences, unfinished pottery, unfinished stone beads, and lumps of raw material—red hæmatite color (for painting pottery), gray *tcriak* (for glazing pottery), lumps of malachite, natural rock crystals (for making beads), ostrich egg-shell (for making disk-beads), and mica (for making ornaments for caps and dresses). The mud seal-impressions must be considered in this same connection. They had been affixed to doors, boxes, pots, and baskets, being placed over a string knot and impressed with scarab and other seals. The abundance of the mud seal-impressions showed that they had been in use for practical purposes, probably connected with trading. From all this material it is only fair to conclude that the fort was the center of a trading and manufacturing post, at any rate during the Hyksos Period, and probably as far back as the VI Dynasty.

While the work on the Defûfa proceeded, a small gang was detailed to search "the plain of potsherds." To my surprise there was no ancient cemetery in it. It was a *plain of potsherds*, nothing more. The layer was never more than a few centimeters deep, and under it was the dark subsoil, possibly alluvial. But finally we came on a late cemetery—a thoroughly plundered burying ground of the first and second centuries A. D. The burials were only just under the surface; and unprofitable as it was, this cemetery taught us one thing—the plain had been denuded about three feet since the second century A. D. It was clear that the layer of potsherds lay on a denuded surface far below that on which lived the men of their day. The potsherds were for the greater part of types known to be as ancient as the Hyksos Period; and as they were so freely mixed with household implements and animal bones, the layer, it seems, must be all that remains of a wide-spread town of that early date. The houses have disappeared to the last vestige throughout the great plain. Only the Defûfa itself remains, and the few walls buried under the *débris* fallen from that mass of mud brick.

Four weeks went in this examination of the western side of the basin. The registers were fully kept—the diary with its sketches, the object register with near a thousand drawings, the photographs of work and objects, the register of photographs, the plans and notes on buildings, and the card record of each grave. In the end the outline of the history of the site had been pieced together from scraps. Artistically speaking, not a single thing had been found—not a thing which could be placed on exhibition in the museum. During the time from February 28th to March 12th it appeared that the whole trip would probably be a failure from the point of view of the museum collections. The only cheering thing was the fact that we were on the site of a great town of the Hyksos Period and earlier—that we had found the period at any rate for which we had come to the Sudan. Then at noon on March 11th I shifted the work to the eastern side of the basin, confident that the flooding of the western side could not rob us of any material of value.

I ordered the men to clear the first stone ring (No. III) north of the Eastern Defûfa. By evening it was finished. The ring of stones was only on the surface. It did not appear to be a retaining wall such as surmounted the Nubian C-group graves. Yet in the very middle was a plundered pit like a C-group pit in size, proportions, and orientation. The next ring examined was farther east, and before sunset on the 12th, although only a dozen plundered graves had been opened, I knew I had the cemetery of the garrison of the Hyksos Period, and that the trip was to be a success in every way.

Permit me to recall the time in which this garrison held Kerma. By 2600 B. C. the Egyptian had already begun his exploitation of the Upper Nile and had been led in military force as far as the present Province of Dongola, the richest area between the Assuan border of Egypt and the tropical Sudan. Gold he certainly brought away, and cattle; ivory, ostrich feathers and eggs, ebony, skins, resins, spices, and incense—all came through the province in trade if they were not produced here. Much of the valuable material brought down by these expeditions was probably of the nature of tribute or blackmail levied on the tribes of the Sudan. It is doubtful if anything of corresponding value was given in return. But Sebni, one of the Egyptian commanders, who led an expedition hither, took "ointment, honey, clothing, oil" to make presents. At Kerma the only certain traces left of these Old Empire military expeditions are the fragments of alabaster vessels with the name of Pepy I. Just west of the Western Defûfa, in an area about thirty feet square, in a layer of *débris* only about a foot thick we found fragments of several hundred stone vessels of the Old Empire, and other fragments were found all over the site. It is quite possible that these were distributed as royal gifts to those chiefs who were properly subservient, or, intended for this purpose, they may have been used in trade by the leader of the expedition. In any case, the great mud-brick fort was probably built by one of these Egyptian expeditions and held by them during their stay. Kerma is one of the places from which the Um-en-Nabâdi gold mines may be reached; it holds the northern entrance of the rich province of Dongola, and would have been a valuable base of operations for such an expedition.

The greater part of our knowledge of the Egyptian expeditions to Nubia in the Old Empire comes from the inscriptions which the governor of the South, Harkhuf, had carved on his tomb at Assuan. His expeditions were under Mernera and Pepy II, successors of Pepy I. But the inscription of Uni, of the time of Pepy I, distinctly states that the king raised levies of soldiers among the fortresses of the negroes of Nubia. It is, therefore, probably only a chance that no account of expeditions of Pepy I to Nubia have been found, and equally a matter of chance that no inscriptions of Mernera and Pepy II were found at Kerma.

During the period of depression in Egypt which followed the reign of Pepy II, it is probable that the Nubian tribes went their own way undisturbed. In the Middle Empire, however, the exploitation of Nubia by Egypt was resumed and placed on a more secure footing. Sesostris III set up a boundary stone of Kummeh, south of Halfa, forbidding any negro to pass northward by land or water except traders and official messengers. This stone marked the southern border of Egypt, but as a matter of course, not the limits of Egyptian activity. The region to the south was certainly laid under tribute and held in subjection by regular garrisons, both during this reign and the succeeding one. At Kerma we found a few fragments of alabaster vases with the names of Sesostris I and Amenemhat I, and a minute frit cup with the name of Sesostris (which one is uncertain). Near the door of the building No. II there was a fragment of an inscription dated in the thirty-third year of Amenemhat III.[1] Scattered over the surface of mounds IX and X we picked up fragments of perhaps twenty-five royal statuettes of the Middle Empire. These had all been intentionally smashed, and in some cases burnt with fire. In mount XI there was a small building, apparently enlarged and restored, and last occupied in the Hyksos Period, that is, in the time of the men buried in the garrison cemetery. So it is quite clear that Kerma was held by the kings of Egypt during the Middle Empire, and that the five buildings now marked down in mounds I, II, IX, X, and XI were built or reconstructed during that time.

Thus we come to the Hyksos Period itself. Much has been written about this period in Egypt, but our real knowledge is small. An unidentified race came in, apparently from Asia, conquered and held Egypt for perhaps a hundred years. But we do not know how far south they held it, nor how their administration was organized.

So we come back to Kerma, and here in the Hyksos Period is a colony of men, not negro, and yet not using Egyptian furniture nor Egyptian burial customs. They razed the buildings of the Egyptians of the Middle Empire; they smashed the statues of Egyptian kings of the XII Dynasty; and they made their graves in the *débris* of an ancient mud-brick structure. They were apparently a fierce and capable race. Their pottery, manifestly made locally, is the finest and most beautiful pottery ever made in the Nile Valley. In fact, I know nothing equal to it previous to the fine, polished paste-wares of the Greeks. Their burial customs are revolting in their barbarity. On a carved bed in the middle of a big circular pit the chief personage lies on his right side with his head east. Under his head is a wooden pillow; between his legs a sword or dagger; beside his feet cowhide sandals and an ostrich feather fan. At his feet is buried a ram, often with ivory knobs on the tips of the horns to prevent goring. Around the bed lie a varying number of bodies, male and female, all contracted on the right side, head east. Among them are the pots and pans, the cosmetic jars, the stools, and other objects. Over the whole burial is spread a great ox-hide. It is clear they were all buried at once. The men and women round about must have been sacrificed so that their spirits might accompany the chief to the other world. None of them, so far as I could observe, bore any marks of violence. Several had their fingers twisted into their hair or had covered their faces with their hands. One woman had struggled over on her back and was clutching her throat. But most of them lay composed as if minded to die quietly, according to the custom of their fathers. I could not escape the belief that they had been buried alive. Who are these people? There are, it is true, a few negroes among the women; but the chief men are all broad-headed and straight-haired. If they are Egyptian, whence comes the strange pottery and the awful burial custom?

It is hoped to submit the bones to Prof. Elliot Smith, who will, without doubt, be able to say whether the men were Egyptians or not. If they are neither Egyptians nor negroes, then there are many possibilities—Arabs, Libyans, a mixed band of adventurers from the north, or even Hyksos. The name of Sheshy, supposed to be a Hyksos king, is found on several of the seal-impressions. But it is not possible at present to reach any safe conclusion on the race of the men of Kerma. The expedition hopes to return there the coming winter and with favoring chance to unravel the mystery. There are other mounds north of the cemetery of the Hyksos Period, and they may give us remains of the earlier garrisons.

[1] By a curious coincidence about the same time the expedition found at our old site of Naga-ed Der a grave stela dated in the thirtieth year of Amenemhat III.

The Clothing Industry*

THE clothing industry of the United States turns out products valued at $500,000,000 every year, and of this enormous quantity over one-half is produced by the State of New York. Many of the large cities of the United States, including New York, Chicago, Philadelphia, and Baltimore, are great centers for this industry, despite the high rents that must be paid there; experience having shown that urban localization is exceedingly important, on account of the dependence of the industry on labor. In the present article we deal mainly with the manufacture of external garments. In the underwear industry the hazards are similar, but not wholly identical.

The chief implements of the garment-workers' trade are the needle, the sewing machine, the pressing iron, and the shears and cutting machines; and the workers may be classified as machine operators, hand sewers, pressers, trimmers, and cutters. There are some fifty processes involved in the making of a garment, but inasmuch as they are largely non-hazardous, we shall mention only those in which accidents are most likely to occur.

* The *Travelers Standard*.

The cloth as received from the mill is first compared with the sample, and if the two agree, it is then critically examined for defects. The principal hazard in this department is that due to the possibility of the workmen being injured when handling the heavy rolls of material.

In some cases the cloth, after it has been examined, is placed in a vat or tank containing water, to shrink it. The amount of shrinkage varies, but it is often as much as from two to four yards in a piece originally 50 yards long. The cloth is allowed to lie in the tank for 24 hours, and is then hung on overhead racks to dry. Stepladders should preferably be used to reach the racks, but ordinary ladders are often employed, and in all such cases they should be provided with safety feet to prevent slipping.

The shrinking and drying processes destroy the finish of the goods, and, to restore it, the cloth, after drying, is treated in a press, sheets of cardboard of a special kind being placed between the successive layers. Pressure is then applied by means of hand wheels, and the cloth is allowed to remain in the press for 24 hours. Some kinds of goods require the application of heat as well as pressure to restore the finish, and when this is necessary flat iron plates are heated in a steam-jacketed oven and placed between the layers. A steam pressure of about 30 pounds is necessary to raise the iron plates to the required temperature. The jackets of the heating ovens should be provided with safety-valves to prevent excess pressure, and these should be examined and tested frequently, to make sure that they are in good working order. Care should be exercised in handling the hot plates, not only to guard against burns, but also to avoid dropping them on the feet and thus causing injuries.

In some factories the cloth is removed from the rolls, after it has been examined, and is folded by machines. Operators of folding machines should never try to clean the cloth, nor even to smooth out a creased portion of it, while the machines are running. It pays to avoid accident by stopping the machines. In particular, the cloth should never be touched, for any reason, near the point at which it goes between the rollers; and to afford protection in case this caution is overlooked, there should be a guard in front of the intake rollers, so that the thoughtless workman may not get his finger caught. All exposed belts, pulleys, gears, setscrews, and other dangerous moving parts of the folding machines should also be effectively guarded.

In the cutting room the cutters take the paper patterns from the designing room, and mark their outlines upon the cloth with chalk, after which the cloth is cut to the chalked lines by shears or by cutting machines. When shears are used they should always have their points turned away from the workman. Most of the accidents with shears occur when the men are doing close work near the edge of the cloth, as they then have to hold the cloth in order to cut it properly.

In making the lower grades of garments, and in cutting linings, mechanical or electrical cutters are used, and fairly good work can be done with them. The maximum amount of cutting for these machines is about five thicknesses of suiting at one operation. As many as twenty pieces of lining may be cut at one time, however, but the work is apt to be poor when this number is exceeded.

Mechanical and electrical cutting-machines cause many serious injuries, and they should therefore be guarded as effectively as possible. When workmen are cleaning or oiling the cutters they should make sure that it is impossible for the machines to be started accidentally. With electrical machines the plug should be disconnected, and when mechanical belt-shifters are provided these should be locked in the "off" position. Workmen should exercise special care when using the cutters near the edges of the material, as it is here that the great majority of the accidents occur. Shears and other implements should never be left on the cutting tables, when not in use.

In the "making" room the workers specialize in different processes, one being a specialist on basting, another on button-sewing, and another on attaching collars or sewing in pockets or sleeves.

Accidents from the puncturing of operatives' fingers by sewing machine needles are quite frequent, largely because the sewing machines are run at an extremely high speed, particularly on certain classes of work. Some manufacturers use electro-plated needles as a safety precaution, believing that the plated needle is less likely to break, and that if an operative is accidentally pricked, the wound will be cleaner, so that the danger of blood poisoning will be correspondingly diminished. It is still an open question, however, whether or not there is an advantage in using such needles. Special care should be exercised by operatives using the pocket-serging machines, and the Reece and other types of button-hole machines. These run at high speed, and they should always be guarded. There are two or three appropriate and effective forms of guards on the market.

The shafting driving the machines should also be carefully guarded, and under the benches it should be entirely enclosed. Foremen often believe that smooth shafting is not dangerous, but this is a decidedly wrong view, because accidents are very common, from women's hair and dresses being caught by rapidly-revolving shafting, when there are no projections on it whatever. Women working about machinery of any kind should wear nets or caps to confine their hair. Furthermore, they should never do up their hair nor change their clothing in the vicinity of machinery of any kind whatsoever, while it is in motion. The following brief account of a recent accident illustrates very clearly the danger from smooth shafting. The names have been changed for obvious reasons, but otherwise the account is copied verbatim from the newspaper in which it appeared.

"Miss Mary Doe, who was at work yesterday afternoon at a sewing machine in the lace waist factory of Black, White & Co., on the third floor of the twelve-story loft building at Laceville, N. J., reached for her barette, which had dropped to the floor near the revolving shaft which operates a row of sewing machines. As she stooped, her long black hair, loosened by the fall of the barette, fell upon the shaft and was wound about it. In a second she had been dragged to the floor and her scalp torn from her head. Dr. Johnson who arrived in an ambulance from the New York Hospital, found Miss Doe unconscious. She revived as she was being taken to the ambulance, and begged to be taken to her home, where her mother was waiting for her. It was said at the hospital last night that her injuries were very serious and might result in death."

Individual motor-drive is rapidly coming into favor for sewing machines, and is taking the place of the mechanical drive and of electric group-driving. In the individual drive the prime mover is directly attached to the sewing machine, and the energy wasted in friction and otherwise is reduced to a minimum. Moreover, when this method of driving is used the consumption of power ceases as soon as the machine stops.

In the pressing department, specialization is even more pronounced than in the making room, inasmuch as one workman may be skillful in pressing sleeves, while another is better qualified to press collars. Most of the pressing is done by hand, but the thick portions of the garments, where the padding comes, are pressed by a machine which is usually capable of producing a pressure of about 1,500 pounds. The table on which the garment is pressed is kept at a temperature of about 200 deg. Fahr., and the iron is heated to about 350 deg. Fahr.

Hot irons and tables, and all other heated objects or implements, should be well guarded, so that it will be impossible for a workman to get burned. The swinging arms which carry the irons for pressing should also have stop-boards so they will not over-swing and hit or burn other pressmen.

Gas irons are used very commonly for pressing, and care should be exercised to see that the flexible tubing connecting them with the gas supply is kept in good condition, and is not allowed to rest against the hot irons. In some of the pressing operations the pressure of the gas as it is received from the city mains is insufficient to keep the irons at a temperature high enough to permit of continuous work. It then becomes necessary to increase the pressure, and this is accomplished by means of a small compressor which is usually located in the machine room and operated by an electric motor. The pressure should be carefully regulated, and a relief-valve should be connected to the compressor to prevent excess pressure. This relief-valve should be examined and tested frequently, and it should discharge either out of doors or into the suction pipe, to avoid contaminating the air of the workroom.

When electric irons are used, all possible precautions should be taken to avoid electrical shocks and burns. The extension cords should be kept in good condition, and all of the switches, fuses, and other similar equipment should be inspected frequently.

Special study should be given to the subject of ventilation, because the conditions in the workrooms are often highly unsatisfactory in this respect. Ventilation is of vital importance in workshops where clothing is manufactured, on account of the large number of workers in a room. Good ventilation promotes safety, because it tends to keep the faculties of the workers active and normal. Furthermore, the operatives will work at higher efficiency if the workroom is properly ventilated.

Careful supervision should be exercised to see that fire escapes and exits are maintained in good condition. The fire escapes should be kept clear and free from obstructions. If they become coated with frost, ice, or snow, they should be thoroughly cleaned. Exit doors should always open outward, and should be arranged so that they may be easily opened from the inside at any time without the use of a key. Entrances, stairways, and passageways should have a width appropriate to the amount of traffic, and they should be kept free from obstacles, and well-lighted during working hours.

Care should be taken to see that the gas is turned off from all gas irons before leaving the work-place, and that the current is shut off from electric irons. Electric irons may be connected with red incandescent lights that will show when the current is on the irons, and will be extinguished when it is shut off. Scraps of cloth, and waste matter of every other kind, should be collected every day and deposited in metal cans having tightly fitting covers.

It is exceedingly important to have supervisors or foremen at the exit doors on each floor during the two leaving periods of the day, to see that the workers file out in order, because many serious accidents have resulted from trivial and seemingly unimportant causes. The workers should be drilled, so that in the event of a fire or a panic they can be handled effectively and conducted out of the building in safety. They should be divided into squads of about fifty members each, and every squad should be in charge of a designated worker, selected with reference to his coolness and good sense, and the confidence that the other workers have in him. Many serious panics might have been averted, if the workers had been organized in this way and drilled from time to time.

Roofs, when used as places for rest or recreation, should be effectively guarded by railings and toe-boards, and nothing should ever be thrown down from them. The railings should be set about six feet back from the edges of the roofs. Skylights should be protected by frames of stout wire netting, and the skylights and windows should be glazed with wired glass.

The Fixation of Poisons by the Central Nervous System*

THE subject of the selective affinity between certain poisons and the central nervous system is one that presents many points of interest, with respect not only to general pathology but also to the pathology of the nervous system. A number of observers have pointed out that in various types of intoxication the nervous system contains an amount of toxin greater than any other part of the body. Ogier and Skolosuboff demonstrated the presence of arsenic in the brain in cases of slow intoxication by this drug and the presence of a large amount of hydrocyanic acid in the brain and spinal cord in cases of rapid poisoning by this substance. Similar observations have been made with respect to lead and the anesthetics.

This subject has been approached from the viewpoint of the microbic poisons, particularly those produced by the diphtheria bacillus, in a series of investigations performed by Georges Guillain and Guy Laroche. The results of their studies were first reported five years ago when they described the fixation of the diphtheria toxin by nerve tissue. A comprehensive survey of this subject is presented by these investigators in *Le Progrès Médical*, July 11th, 1914. In their original work they had shown that the medulla oblongata of patients who have died in the course of severe diphtheritic paralysis contains toxic substances that are not present in the case of individuals dying from other affections. The toxicity of the above substance was determined by the fact that emulsions of the medulla oblongata in physiological salt solution when injected into guinea pigs caused the death of these animals. There is a direct path of the diphtheria toxin from the pharynx by way of the nerves to the spinal bulb. The affinity between the diphtheria toxin and the nerves is a particularly close one. Thus these investigators in collaboration with Grigaut showed that if diphtheria toxin is brought into contact with nerve tissue the toxic properties imparted to the latter cannot be removed even after repeated washing with physiological salt solution. It was found that the phosphorized lipoids of the phosphatid group (lecithin, cephalin) have an intense fixing power with respect to this toxin, while the non-phosphorized lipoids, such as cholesterin, are entirely inactive in this respect. Diphtheria toxin when combined with nerve tissue undergoes a marked activation of its toxic properties, the period of inoculation of the experimental disease and the duration of the latter being considerably shortened.

The toxin of tetanus is likewise fixed by the nerve tissues, but is contrasted with the diphtheria toxin in one respect, namely, the nerve tissue of an animal or human being that has succumbed to tetanus, if inoculated into a laboratory animal, will not evoke the disease unless the amount of tetanus toxin present exceeds the amount that has been neutralized by the nerve tissue. Another distinguishing characteristic is the fact that the phosphorized and non-phosphorized lipoids, with the exception of protagón, possess but slight fixing power with respect to this toxin, while the albuminoids are strongly fixative. The clinical differences between diphtheria and tetanus are probably to be explained on the basis of the above differences; the diphtheria toxin which causes paralysis is fixed and activated by the phosphorized lipoids, while the tetanus toxin which evokes muscle spasm is partly fixed and neutralized by the protein substances.

The poisons of the tubercle bacillus are fixed and activated by the nerve tissues. Tuberculin when mixed with nerve tissue has its power increased as much as fourfold. This fact may serve to explain some of the phenomena of tuberculous meningitis. The adult or the child affected with the latter dies before a local defense has been set up. Frequently at autopsy on cases of tuberculous meningitis there are observed but few local lesions; there may be only a congestion of the meninges. The rapidity and intensity with which the convulsive and paralytic symptoms of tuberculous meningitis develop are to be attributed to the avidity with which the poisons of the tubercle bacillus combine with the nerve tissue, particularly in the regions of the medulla and the basal ganglia. It has been shown that in the nerve centers the tubercle bacilli are quickly destroyed. This bacteriolysis which is a mode of defense nevertheless sets free toxins which become more potent by being combined with the cells that are responsible for their liberation.

This subject is one of engrossing interest and eminent clinical importance, and many of its ramifications can only be hinted at. One may allude to the selective affinity of strychnine for the cells of the anterior horns of gray matter of the spinal cord, to the fixation of alcohol by the brain, to the avidity with which chloroform and ether combine with nerve tissue, and to the predominance of lead in the same tissue in cases of plumbism. Oxalic acid is likewise seized by the nerve tissue to a greater extent than by any other part of the body. The symptoms of anaphylaxis are to be attributed largely to the fact that the anaphylatoxins expend their virulence upon the nerve cells with which they combine.

Important from many viewpoints of internal medicine is the hypothesis that endogenous poisons may behave in the same manner as those mentioned above. Nervous symptoms such as paralysis, tremor, convulsions, contractures, delirium, etc., are probably the result of a fixation of toxic bodies by the nerve centers. This is a conception of fundamental significance in psychiatry and deserves extended investigation.

* Reproduced from the *Medical Record*.

Peat Fuel for Locomotives

THE Swedish railway authorities have been investigating pulverized peat as a fuel for locomotives for several years with a view to ascertaining its suitability for various types of locomotives and its cost as compared with coal. One of the locomotives on the State Railway was altered for the purpose, and has been in use for some time in regular working between Stockholm and Upsala with favorable results, both from a technical and an economic point of view.

Fig. 1.—Gyro mounted with a Cardan universal joint for demonstrating gyroscopic precession.

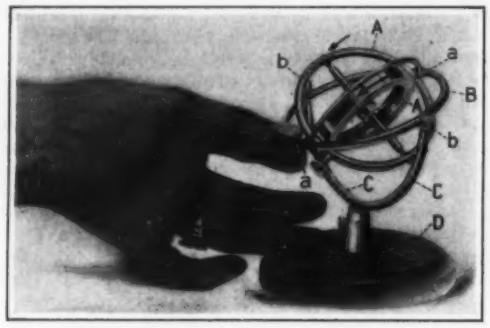


Fig. 2.—Precession carrying the upper end of shaft to the left by tilting the Cardan ring downwardly.

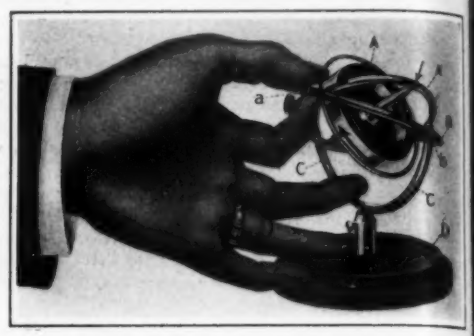


Fig. 3.—Precession carrying the upper end of shaft to the right by tilting the Cardan ring upwardly.

The Electrically-Driven Gyroscope in Marine Work—I*

The Toy of Yesterday Now a Valuable Scientific Instrument

By H. C. Ford

UNTIL a few years ago the gyroscope was little known or heard of except as a child's toy, although as far back as 1852 its action was investigated by the French scientist Foucault, who published the results of his experiments, in which he laid down very clearly the laws of its action.

His first law states that any gyro or spinning body possessed of three degrees of freedom, i. e., free to rotate about a spinning axis and two other axes all normal to each other, will tend to maintain its axis of spinning fixed in space and may therefore be used to show the rotation of the earth. He also demonstrated that when a gyro was given a forced motion of rotation about one of the axes, the gyro would powerfully resist such force while at the same time tending to place its axis of spin in line with or parallel to the axis of the impressed force. This motion, which takes place about an axis at right angles to that of the impressed force, is known as gyroscopic precession, and always occurs in such a manner as to bring the direction of spinning the same as that of the impressed force, and by the shortest path. In other words, if the spinning axis were horizontal and the axis of precession vertical, then the gyro, by virtue of the impressed force of the earth's rotation, would turn about in azimuth and place its axis of spin as far as possible in line with the earth's axis (1. e., upon the meridian) after the manner of a true compass. This strange resisting force with its unexpected motion of precession at a different angle and apparently unrelated to the impressed force, is in reality a simple and logical result of the inertia of the moving mass. Its explanation is well known and follows directly the application of Newton's laws.

It is not, however, the purpose of the writer to go into abstruse theoretical considerations. Suffice it to say that the law of precession explains fully the observed facts with regard to parallelism of the two axes, and is well illustrated in the accompanying figures, Nos. 1, 2, and 3, which show an ordinary gyroscopic top *A* mounted in a Cardan ring *B* by pivots *a*, the outer pivots *b* being supported upon a fork *C* rigidly mounted upon the base *D*. Suppose the wheel with all parts symmetrical, as in Fig. 1, is rotating clockwise, viewed from above, and we grasp the Cardan ring and depress it on axis *b* to position shown in Fig. 2. First it will be found that the Cardan ring is possessed of a quite remarkable amount of rigidity and opposes the forces tending to tilt it. However, as these forces are applied, and though the ring *B* is moved only slightly, yet the gyroscope is seen to immediately swing vigorously through a wide angle upon its axis *a* to the position also shown in Fig. 2. Upon lifting the Cardan ring the gyro will again be seen to swing vigorously in the opposite direction until arrested by the stop as shown in Fig. 3.

For nearly half a century after Foucault had demonstrated its action, the gyroscope was put to no practical use. The late American author and scientist Hopkins, whose writings were published for many years in the SCIENTIFIC AMERICAN, was the first to drive a gyroscope electrically. He was able to enlarge on Foucault's experiments and obtain much more persistent results with his continuously driven wheel.

The first serious application of the gyroscope in engineering work was by Obrey, an Austrian naval officer, who made use of the gyroscope to steer torpedoes. About 1903 Dr. Schlick, a German engineer, proposed the use of the gyroscope for stabilizing ships against rolling, and built a number of experimental plants which were tried out with some little success. At about the same time Lewis Brennan brought general public attention to the gyroscope by his announcement of a railroad car that would maintain its equilibrium on a single rail. A car of this type was exhibited in this country in 1910 and the subject of monorail traction was much discussed in the press at the time in connection with the possibilities for high speeds which were claimed for this invention.

Practically all of the serious applications of the gyroscope, and by far the most important of its uses at the present time, have developed in marine work. These are, the steering of torpedoes, the use as a compass, and the use for stabilizing and controlling the motions of ships, the last two of which will be discussed more fully.

Several minor applications have been made, such as (1) stabilizing of various instruments, telescopes, etc, against oscillations when mounted on a rolling ship; (2) stabilizing of a pendulum carrying a pen for recording the angles of roll and pitch of a ship; and (3) stabilizing a horizontal mirror for use as an artificial horizon in taking observations at sea. Some very valuable results have been accomplished along these lines, but the limits of the present paper will not permit of more than a brief mention. Various attempts have also been made to stabilize a body with three degrees of freedom for use in the direct determination of latitude and longitude, but so far as is known, without practical success.

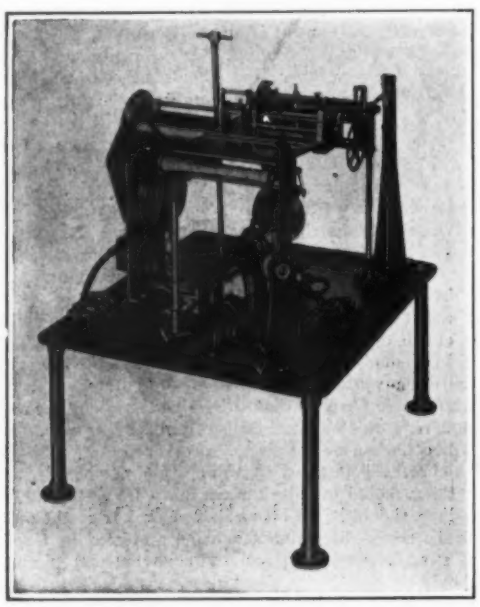


Fig. 5.—Instrument for recording the rolling, pitching, and yawing of vessels.

Fig. 6.—Gyroscopic artificial horizon,

Fig. 4 shows a form of telescope used on board ship for obtaining bearings of distant objects, which has been stablized by means of gyroscopes so that it is entirely unaffected by motions of the ship in any direction.

Fig. 5 shows one of several types of apparatus which have been constructed for recording the rolling and pitching motion of a ship upon a moving sheet. In the instrument here shown, records of the azimuth as well as various time markings are made simultaneously upon the same record sheet.

Errors are frequently introduced in navigation when measuring the altitude of a heavenly body above a false horizon caused by mist or by the mirage effect of the heated air on a tropical sea. Very frequent observations of the sun or heavenly bodies could be taken were it not that the horizon is obscured by low-lying banks of fog or darkness.

Fig. 6 illustrates a gyroscopic artificial horizon which provides a means for eliminating these errors in observation and makes it possible to measure accurately the altitude of any heavenly body that can be seen, whether or not the horizon is obscured.

The automobile torpedo, as is well known, depends upon a gyro steering gear for its directive power, and would, in fact, be utterly ineffective for its purpose without such a device. The importance of the torpedo in warfare is of course recognized, so that the great value of this application of the gyro needs no further comment.

The gyro compass shown in Fig. 7 is depended upon for use under battle conditions where the magnetic compass could not possibly be employed, due to the large masses of magnetic material constantly being moved about in proximity to the compass. As an instrument of navigation, the gyro compass has also proved of great accuracy and value in enabling the ship to be held steadily upon its course irrespective of wind, sky, or sea. The foreign navies are also rapidly adopting the gyro compass, and it seems certain that its use on all of the larger steamships and ocean liners will be found in a few years when its great advantages have become more widely known.

The very high development of the gyro compass during the past few years has been largely due to the efforts of a pioneer in the electrical art, Mr. Elmer A. Sperry, whose long and interesting experience with gyroscopic phenomena and belief in their engineering possibilities led him to devote practically all of his time to its development.

It has been the privilege of the writer to be associated with Mr. Sperry for several years past in this work, during which time a plant has been organized and equipped for the design and manufacture of many forms of gyroscopic apparatus.

A number of workers abroad have also been laboring with great persistence and some degree of success to

* Paper read before the American Institute of Electrical Engineers and published in the *Proceedings* of the Institute, vol. 33, No. 6, p. 873. Copyright, 1914, by American Institute of Electrical Engineers.

solve the many physical problems involved in translating the idea of Foucault into concrete terms of steel and bronze which will function under the extremely severe conditions on shipboard.

The nature of the problem is indicated when one realizes that the gyro compass is so sensitive that it responds instantly and with the highest degree of accuracy to the very slowly impressed angular motion in space about the earth's axis four thousand miles distant, while at the same time it remains indifferent to the angular movements of the ship several hundred times greater in intensity.

In view of the expensive use of the gyro compass and the nature of the problems involved in its development, it may be of interest to look into the theory of its action somewhat briefly and then to note some of the many special construction details and various electrical devices employed in this highly organized instrument.

Fig. 8 shows a small device which may be used to demonstrate the action of precession in the gyro compass. In this device we have a small disk marked with the cardinal points to represent a compass card and mounted upon a ring swiveled to rotate on a vertical axis within a hand-supporting frame. The ring carries a wheel which spins upon a horizonal axis fixed in the ring parallel to the N-S line of the compass card. If the device is held extended in the hand while the demonstrator turns slowly on his heel toward the left, we may consider his body as the axis of an imaginary earth and his head as the virtual north pole, since his rotation would always be easterly.

If the device is extended with the axis of the card perpendicular to the body at the waist line, the compass may be considered as located approximately at the equator. If held opposite the shoulder, with the axis of the compass card or handle making an angle of 45 degrees with the body, the compass would be represented in operation at latitude 45 degrees north.

Now when the wheel has been made to spin in a clockwise direction viewed from the south side of the card, if the device is carried about in the hand as above, the card will immediately orientate or turn on its axis to bring the north side toward the virtual north pole.

If the demonstrator should reverse his direction of rotation and turn toward the right, which would now represent east, we should have to consider that the north pole had been shifted to his feet, and if the little model is a true compass it should also reverse its direction and point to the new pole. This is what actually occurs, for the gyro compass not only holds to the meridian when placed thereon, but is actually possessed of a powerful north-seeking tendency many times greater than that of the magnetic needle.

The above demonstrates the elementary action of the gyro compass on an imaginary earth, the length of whose day is about twenty-four seconds. Under such conditions this little compass is ideal in its simplicity.

When, however, we are considering an instrument of precision, for actual use on a ship rolling, pitching, and yawing in a heavy sea, or maneuvering at various speeds in every possible direction, the matter of picking out this demonstrator who will keep his body parallel to the earth's axis under such conditions and rescue a struggling directive force from the waves, is a somewhat larger contract.

As a matter of fact, many and serious are the mechanical and theoretical problems which had to be solved in producing a practical compass for navigation. For example, when mounted on a ship steaming rapidly north, say, the gyro axis does not point true north, but has a certain deflection, for the reason that the actual motion in space is no longer due easterly, but is about a resultant axis somewhat to the westward of the earth's axis. The amount of this deflection, which is a variable, depending upon the speed, course, and latitude of the ship, has been exactly determined for all conditions.

In the Sperry compass a device is employed which corrects for the above factors and automatically introduces this correction into the compass readings, which are therefore always made accurately upon the meridian. Other special mechanical devices are employed for the following purposes, among others:

(*a*) To provide a substantial mounting for the gyro element with the highest degree of sensitiveness.

(*b*) To damp oscillations in azimuth.

(*c*) To compensate various acceleration pressures.

(*d*) To prevent errors caused by retardation of the wheel.

(*e*) To set the compass quickly on the meridian even when the direction is unknown.

(*f*) To prevent errors due to persistent oscillations in certain oblique planes.

(*g*) To admit of determining the speed of the wheel by observation.

Space will not permit of a further study of the many theoretical problems involved nor of a detailed description of all the mechanical devices employed in this solution.

The general arrangement of parts constituting the Sperry gyro compass is shown in Fig. 9, which for greater clearness in illustrating the various functions has been simplified by the omission of electrical circuits and minor details.

The gyroscope wheel is mounted to rotate on a horizontal shaft *A* within the casing *B*, which is pivoted on the horizontal axis *C* through its center of gravity and carried by the frame or vertical ring *D*.

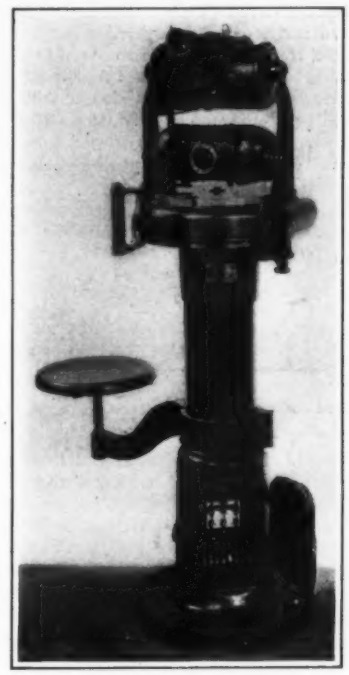


Fig. 4.—Telescope stabilized by gyros.

Fig. 7.—Master compass with covers removed.

Fig. 8.—Model for demonstrating the action of the gyro compass.

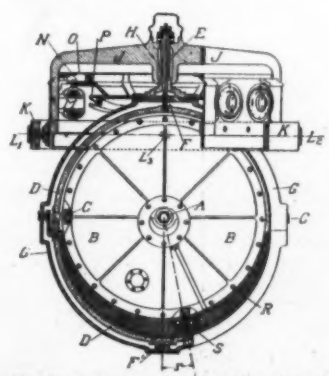


Fig. 9.—Method of mounting the directive element.

The ring *D* is suspended by a torsionless strand *E* and guided by bearings *F* and *F'* to allow a free oscillation of limited amount about its vertical axis within the frame or "phantom" *G*, so called because of its characteristic action as a "shadow" in following up each motion of the ring *D*. The phantom *G* has a hollow stem *H* to which the strand *E* is attached at its upper end, and the stem forms a journal for rotation in azimuth with respect to the supporting base frame *J*.

The frame *J* is mounted to swing in the binnacle by the usual Cardan suspension, consisting of the ring *K* and suitable bearings *L1*, *L2*, *L3*, and *L4*, the last not shown.

The frame *J* carries a "follow-up" motor *M*, driving a master gear *N*, forming a rigid part of the phantom *G*, whereby the latter is positively driven in azimuth to respond to any movement of ring *D*.

The ring *D*, which with the wheel casing is termed the "element," carries a pair of electrical contacts in the form of trolley wheels, which co-operate with stationary contacts mounted upon the phantom *G* for the purpose of controlling the follow-up motor *M*, the electrical connections not being shown in the figure.

The power-driven phantom *G* is thus automatically controlled so as to respond instantly to all movements of the sensitive element, and in fact to all relative movement in azimuth between the ship and the gyro.

This characteristic of the phantom enables it to be used for various important functions, namely, to carry the scale or card *O* and a cam *P* forming part of the automatic correcting device. The power drive is also utilized in operating the transmitter for the repeater instruments, and in overcoming friction of the slip rings needed to carry current to the gyro.

Since the phantom *G*, though at all times rigidly anchored to the binnacle, stands in practically constant relation to the sensitive element as regards motion about the vertical axis, but is nevertheless entirely separate therefrom, it serves as an anchorage for producing stresses to restrain and correct the movements of the sensitive element. This is accomplished by means of a yielding connection between the phantom *G* and the gyro case *B*, in the form of a pendulum or bail *R*, supported by and forming a part of the phantom. The point of attachment *S* to the gyro casing is located in a certain position eccentric to both the vertical and horizontal axes of the gyro. By this means several most important results are obtained, including positive orientation and the prevention of oscillation.

The complete electrical equipment of the compass system which will now be considered comprises:

1. A voltage regulator of special design.
2. A three-phase alternating-current generating set.
3. A 20-volt direct-current generating set.
4. A direct-current emergency service.
5. An alarm system.
6. An automatic control and protective system.
7. Specially designed controlling switches.
8. The gyro motor.
9. A servo motor or follow-up system.
10. A secondary transmitting and receiving system.

Fig. 10 illustrates the various parts of the Sperry gyro compass system for use on a battleship. The master compass and controlling apparatus are installed in a protected portion of the ship behind heavy armor. The repeater compasses are mounted at various points about the ship at the different steering stations. On a battleship, for instance, repeaters are supplied at the main steering platform, others on the bridge for taking bearings, one in the conning tower for steering during battle, one in the steering engine room at the stern of the ship, and in some cases one or more additional repeaters in ships provided with additional steering stations.

The compass is also used in connection with various other instrumenis for obtaining and recording various data.

(*To be concluded.*)

Heavier Rails for Railways

It is apparent that the rapidly increasing weights of both locomotives and loaded cars of all descriptions will soon make a heavier rail necessary. Rails weighing 110 pounds per yard have already been introduced on the Lehigh Valley road on heavy grades and sharp curves, and now the Pennsylvania Railway is trying a rail that weighs 120 pounds, which is far in excess of the 100-pound rail that, with few exceptions, has been the heaviest heretofore used. The new Pennsylvania rail has 41 per cent of the material in the head, 22 in the web, and 37 in the base. The sides of the head have been given the steep slope of 8 degrees and the top has the short radius of 10 inches, the corner radii being $\frac{7}{16}$ inch. The fishing angle under the head is one of 18 degrees, and above the base one of 13 degrees. The height is 6¼ inches.

The Origin of Waves*

Their Propagation and Their Force

By Edgar De Geoffroy

RUDYARD KIPLING, in his description of "The Ship that Found Herself," says:

"As soon as she met the lift of the open water, she naturally began to talk. If you lay your ear to the side of the cabin the next time you are in a steamer, you will hear hundreds of little voices in every direction, thrilling and buzzing, and whispering and popping, and gurgling and sobbing and squeaking, exactly like a telephone in a thunderstorm."

All these complaints which rise from the very bowels of a ship are signs of the fatigue and labor of the material entering into her intimate structure, under the efforts of the waves.

Those deep wrinkles, which at certain times overspread the mobile physiognomy of the ocean, are of great variety, and hence produce various effects upon a vessel. Sometimes short and crowded, the liquid undulations that beat upon her seem, with their limited dimensions, devoid of danger; but on the contrary their disheveled crests, their steep flanks, betoken the fury of the "breaker." Again, long and majestic, they seem of alarming size; but their rounded summits and gentle slopes rob them of the violence of the shorter type of wave, and the ship rises easily as they sweep beneath her.

These ridges on the surface of the water arise as the result of two causes, one artificial and one natural. The former is the movement of the ship; the latter the friction of the wind. The vessel's prow, cleaving the water, pushes it aside to right and to left, and the liquid thus suddenly displaced vibrates and oscillates with the shock, giving rise to the billowy waves at the bow of the ship. The more violent the rupture of equilibrium—*i. e.*, the faster the movement of the ship—the more powerful will be these waves. They gradually fade out in "echoes" as they recede from the vessel, but they never cease to accompany her, and, by their lifting motion, to offer more or less impediment to her progress.

But the principal cause of waves, and the one most fraught with danger, is the wind. Before you lies a dormant sheet of water, flashing in the sun and seeming perfectly still; but bend over this mirror-like surface with a magnifying glass, and you will be surprised to discover myriads of minute dimples—infinitesimal vortices, miniature cyclones, showing that evaporation never ceases—a fact further evidenced by the clouds floating overhead.

As the wind rises and the aeration of the surface goes on at a more rapid rate, evaporation increases; the surface of the water becomes honeycombed with little hollows, ever more numerous, offering a greater hold to the moving air. In the midst of these asperities each particle of water pushed by the wind tends to override the one in front of it. Moving across, it will find itself sheltered from the frictional impulse of the air and will return in a downward course toward its original position, seeking to fill the vacancy which its displacement had caused. Thus it will have described a tiny orbit, analogous to those of the heavenly bodies.

The majestic swell of the ocean which, after the wind has fallen, continues to sweep toward the horizon in broad furrows and rounded crests; this swell which is the continuation, in virtue of inertia, of the movement given to the heavy masses of salt water by the tempest, and which grows regular as it gradually subsides, teems with little orbital movements of the water-drops. From the surface down to a certain depth, each liquid particle describes incessantly, in its place, a little closed curve.

Imagine a wheel moving along the ceiling of your room and beside a wall, in such a manner that a nail transfixing one of the spokes scratches the wall with its point. The resulting curve will represent the profile of a wave. If the wheel revolved without advancing, the nail would describe a circular orbit; it would then represent a particle of water oscillating in its place. If, on the other hand, the wheel advances, the nail traces the outline of a series of droplets, a chain or thread of water, all the particles of which were in the same horizontal plane when in a state of repose. The distance separating two summits or crests of the undulation is called the wave-length; half a wave-length is therefore the horizontal distance from a crest to a hollow. The height of the wave is the vertical elevation of a crest above the next hollow.

The undulation is not, however, stationary. It runs along the water like the undulation of a rope which, when lying on the ground, has had a violent up-and-down motion given to one of its ends. Yet the water itself remains in place, alternately rising and falling, as may be readily seen from the movement of a floating cork or of a swimming bird, which seems to defy the waves as it rides upon them. Suppose you examine the profile of a wave during a very brief interval of time, as, for example, during a flash of lightning. It will appear motionless, like the trace made by the wheel on the wall of your room. After a brief disappearance you see it reappear by the fugitive light of another flash, but not in the same place; it has moved horizontally. Without quitting their orbits, the water particles of the liquid chain have all revolved through the same angle at the same time; consequently, at the end of a certain interval, when all the particles have described a semicircle, the wave-crests will be replaced by hollows and the hollows by crests. When the whole orbit has been described, the waves will have advanced their own length, and their profile will appear unaltered, but in reality each hollow will have replaced the next hollow, and each crest the next crest. All these regular undulatory forms are really *limiting* forms, attained only when the wind which lifts the waves has subsided.

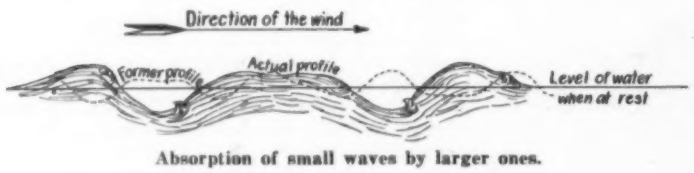
We have seen how the water is set in motion when the wind first blows upon its tranquil surface. First appear mere wrinkles—the effect of what sailors call "cat's-paws." The impulse of the air which drives the liquid particles from their position of repose is not of the same intensity at all points; local variations determine the inequality of these wrinkles, which, growing larger, become waves. The larger waves offer more surface to the wind than the smaller, move more rapidly than the latter, overtake and absorb them, and thus swell more and more, growing at the expense of those ahead of them. However, on the windward slopes of these large waves other undulations continue to form by the same process as on a tranquil surface. These secondary undulations are slower in movement than the waves on which they arise, because they are smaller; hence, as soon as they form, they begin to lag behind the general movement, separate from the mother wave, and are gradually overtaken by the wave following, which absorbs them. It is for this reason that, in a stormy sea, you will sometimes see two or three nearly regular waves, of the same duration of passage, followed by a great wave of longer duration, and again by smaller and more regular waves.

If the wind suddenly shifts there is veritable chaos. The waves spring up at random, without apparent cause, and are torn into spray by the fury of the blast sweeping in a direction opposed to their previous motion. There is a shock and a struggle between the waves pressing forward with the momentum of their previous course and the wind driving them back, while the foaming sea seems to be beside itself with rage at this sudden resistance.

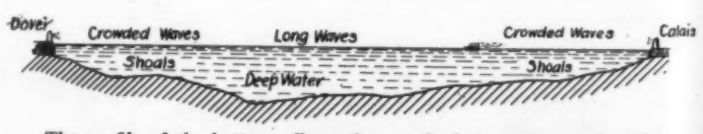
If the wind dies down, the disorder gradually disappears and each system of "choppy" waves becomes a system of swells, and these swells react on one another, as above explained. The discord lasts until the moment when, as if under the invisible baton of the leader of a vast orchestra, a single note or measure prevails, and all others blend into it. The phenomenon becomes a har-

Influence of depth of water on shape of waves.

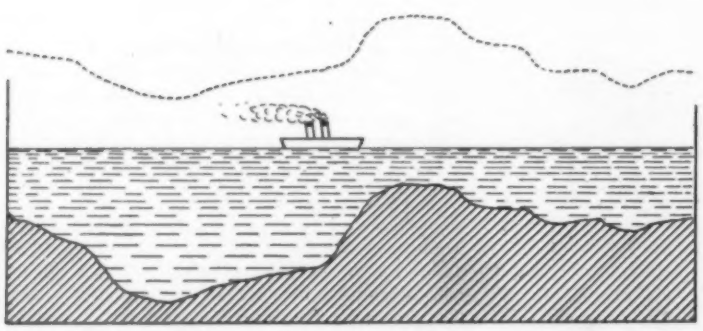
* Translated for the SCIENTIFIC AMERICAN SUPPLEMENT.



Absorption of small waves by larger ones.

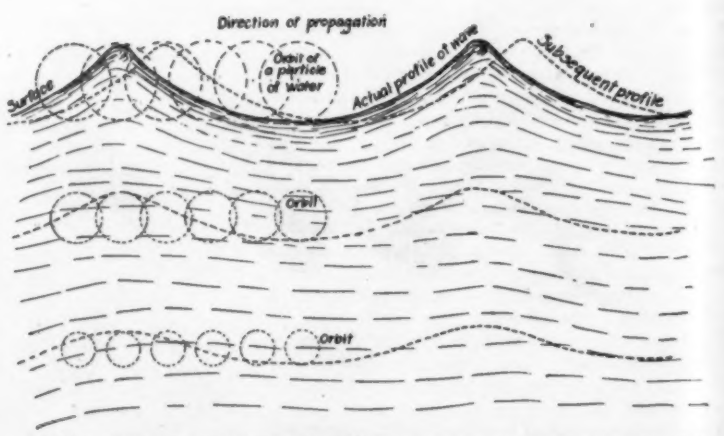


The profile of the bottom affects the speed of steamers crossing the English Channel.



Influence of a submarine ridge on the progress of a ship.

The dotted curve shows the variation in the height of the waves produced by the vessel. The shallower the water, the higher the waves and the greater the resistance they offer to the advance of the ship.

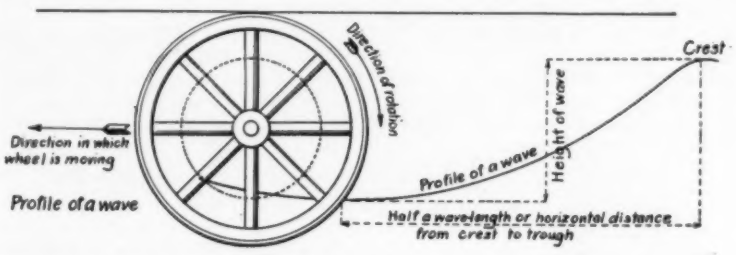


Orbits of water-particles and profiles of waves at different depths. The movement of the surface is repeated below, but with diminishing amplitude.

mony, and the beautiful ocean swell, slow, majestic, and regular, presents itself for our admiration.

The highest waves ever observed attained heights of 40 to 45 feet. These are met with especially in the neighborhood of the Cape of Good Hope, and are capable of hiding from each other two vessels of average length when both are in the trough of the sea.

The phenomena seen at the surface are reproduced, but with less amplitude of motion, at the various levels beneath. The orbits of the water-particles are still circular, but their size diminishes rapidly to the vanishing point—


Direction of rotation
Direction in which wheel is moving
Profile of a wave
Crest
Height of wave
Profile of a wave
Half a wavelength or horizontal distance from crest to trough

Imagine a wheel moving along the ceiling of a room; the point of a nail, passing through one of the spokes, will trace a curve on the wall exactly like the profile of a wave.

a state of absolute repose. The depth beneath which the awful silence and calm of the submarine abysses prevail is not always the same. It depends upon, and increases with, the amount of agitation at the surface. In general, on descending to a depth equal to half the length of the waves we find orbits not more than a hundredth as great as at the surface, i. e., the beginning of comparative calm. Below an average swell, say, 300 feet from crest to crest and 10 feet in height, at a depth of 150 feet the oscillations are not much over an inch in extent, and the motion is therefore insignificant.

If the sea-bottom is near the surface, the mechanism of the waves will be profoundly modified. Moreover, the bottom will undergo erosion, an examination of which will serve to determine the depths reached by the movements of the water. Thus, at Cherbourg, in rough weather, it is necessary to descend to more than 25 feet beneath the trough of the waves before one finds the bottom undisturbed. On the coasts of Algeria, pure sand is not disturbed below a level of 50 feet, while muddy (i. e., finer) sand is not disturbed below 100 feet. In the open sea, light sands are moved at a depth of 130 feet in the English Channel, 160 feet in the Mediterranean, and as much as 650 feet in the ocean. These depths, which appear enormous, are really trifling in comparison with the abysses of 2,000 fathoms which have been measured in the Mediterranean, and those of 4,000 to 5,000 fathoms found in the ocean.

As these figures show, the depth to which the disturbance extends from the surface increases with the depth of the sea. This relation is connected with the fact that closed seas, such as the Mediterranean, the Black Sea and the Caspian, have waves of less length and height than the ocean, with its unlimited horizons and swells of enormous dimensions. The reason is that, as we have already seen, the length of the waves and the depth of sensible disturbance depend upon each other, and throughout the greater part of these closed seas the depth at which all disturbance must cease finds itself limited by the presence of the bottom, which allows the water-particles only to move to-and-fro, scraping the ground. This forced abridgement of the depth of sensible disturbance also limits the wave-length. While in deep water, with nothing to hamper its motion, the latter is large and free, the swell long, the waves far apart, very round, and relatively low; over shoals, on the contrary, the movement appears pressed together horizontally; the wave-length diminishes; the comparative height of the waves appears to increase, though in reality it decreases, but less rapidly than the length, so that the hollows become more pronounced, the slopes steeper, and the crests more pointed. If the bottom gradually rises, the progress of the base of the wave is retarded by the friction of the ground, while the crest preserves its original motion. Thus there is a tendency to lean to one side until finally the summit topples over, and, losing the sharpness of its contour, becomes fringed with foam. Then, in a bubbling and frothy mass, the wave "breaks." This correlation between the depth of the water on the one hand, and the length, height, and velocity of the waves on the other, is so intimate that, when waves are produced by the motion of a vessel, the latter's advance shows the influence of the profile of the sea-bottom.

The faster a vessel travels, the farther apart are the waves she produces; they move freely away from the hull and offer less impediment to her progress. On the other hand, the more slowly she travels, the more crowded will be the waves, and the motion of the vessel will be proportionately impeded. Navigation at high speed is, however, laborious in shoal water for the reason that the long waves produced are out of proportion to their possible depth, as limited by the bottom. Thus in crossing the Channel, a steamer starting from Calais finds it more difficult to attain and maintain her full speed than one starting from Dover, the strait being deeper on the English side than on the French. Consequently, a little more coal and a little more time are consumed in going from France to England than in crossing in the opposite direction, and this result is independent of the state of the sea, current and tide.

This influence of the depth of water explains the mysterious shock which, on one occasion, was felt by a vessel passing at full speed over a submarine ridge. One would have said that she had collided with some floating obstacle; the number of turns of the screw suddenly diminished, as if the water had all at once become more viscous and hence more difficult to push aside. It, before and after this happened, it had occurred to someone to observe from moment to moment the height of the waves, it would have been seen that their uninterrupted succession reproduced above water a profile suggesting a slightly distorted image of the contour of the bottom over which the vessel was passing.

What mariners dread most, however, is not these phenomena of more or less moderate violence, which are observed even in fine weather, but the breakers or surf which occur in shoal water during a storm. Here we have to do with forces wrought to a frenzy—condensed, concentrated, so to speak, in a relatively shallow layer of water, and hence more violent in their reaction.

The force of the waves is proportional to their length, and to the square of their height. Thus while, with a given height, a wave 300 feet long has twice the force of one 150 feet long, with a given length, a wave 20 feet high will have four times the force of a wave 10 feet high. In other words, it is the height of the waves that is the most redoubtable feature of a stormy sea. Hence the lofty, toppling breakers are most to be dreaded in navigation. In the Indian Ocean, these may be met with nearly four miles off-shore, and in water 50 deep feet.

Let us try to form an idea of the force of a relatively moderate wave 300 feet long and 10 feet high. On its gliding, undulating surface let us imagine a little section 3 feet square. Do you know what the energy stored up in this small space is capable of doing? It is able to hurl a mass of two pounds nearly three quarters of a mile into the air. If the height of the wave is doubled, its force becomes increased four times. Think, then, what its violence will be when it breaks. When we remember that the area of the sides of a ship may be more than 5,000 times as great as the little surface we have just been considering we will see with what care it is necessary to study, not only the shape of the vessel's hull and her general structure, but also the nature and mode of assemblage of even her smallest parts.

Dead Men Do Tell Tales*

By Davina Waterson

ONCE upon a time many a murderer was acquitted and many an innocent man hanged, because, to all appearances, they had or had not, been guilty of the crime.

But to-day an assassin has to reckon with the physicist, the chemist and the Rontgenologist, who start off on his track and force him to face damning, dispassionate scientific facts, but, with equal zeal bring these facts to clear a miserable man protesting his innocence, yet condemned beforehand by circumstantial evidence. Now, if a man is found walking quickly away from the place where a body has been found, and if the man has blood stains on him and on his pocket knife, naturally he is the murderer, so why spend a fee on an expert to prove the contrary?

Just such a case occurred in France. It was no use the man saying he had poached a rabbit, made a stew and burnt the skin and bones to avoid possible detection. He was condemned because the bloodstains and a known hatred for the victim shouted guilty! Then came along a physicist and showed the blood to be that of a rabbit, for, by the unique methods of two professors, E. T. Reichert and A. P. Brown, it can be determined to what species of animal, bird or reptile the blood belongs, since every species has distinct crystallization. Experts claim to distinguish differences of nationality and it is no illogical optimism to state that their claim to prove consanguinity may prove to be correct. If Jacob had been able to set a scientist to work on Joseph's coat the brethren would have been confounded, and Reuben, the conniver at deliverance, extra triumphant. Ever since those days the malignant have tried to fix guilt on innocency by spattering the blood of animals on clothes or weapons, but it never can happen again in civilized countries.

A little while ago a mother murdered her little girl in a lonely spot and "murder by person or persons unknown" was the verdict. A suspicious neighbor, who disliked the woman, took up the search privately and one day found a blood-stained knife near the house. "Why, that's the knife I used to kill a rabbit last week. I put it there in the wall meaning to clean it," cried the mother.

Submitted to an expert, the knife told of human blood, blood shed a year ago, and the terrified mother confessed her guilt. It is now over seven years since an Italian physicist, A. Lechanarzo, perfected the method of determining the age of a bloodspot. Would Rizzio's blood, said to be renewed every year on the floor of Holyrod Palace, stand an investigation? I think the tourist, enjoying the induced thrill of horror, would rather the scientist kept out of the way!

Mutilation of a body is not always effectual, and has occasionally, by its very dexterity, convicted the real offender. A murderous butcher will, naturally, cut up his victim with precision, and a medical student or surgeon would do it in a skillful fashion. The mutilations by Jack the Ripper showed him to have considerable anatomical knowledge.

A physical defect, engendered by disease or habit, often guides an expert in detection, but when a man cuts his old father into 130 pieces and buries these separately in garden and field he naturally expects to lull suspicion, especially when he daily expresses surprise that the aged parent does not return from Paris.

Six months after the deed a farm hand dug up a hand, no clue apparently, except that a friend, a medico-legal expert, took note of certain callosities in the palm, rather peculiar ones, and soon after begged of the son his father's stick as a memento. The curiously carved knob exactly fitted the skeleton hand and the son was convicted of the murder. In the same way the body of a mutilated nun was identified by the callosities on the knees produced by constant kneeling; and Sir William Fergusson proved the identity of Livingstone (though it was hardly doubted) by showing an old ununited fracture in the left humerus. The structural deformations induced by occupation, often lead to the identification of a murdered man when he has been, say, a tailor, a barber or a shoemaker, while the condition of the teeth may show the victim to have been a printer or a potter, owing to the plumbism engendered.

Now, if a man is found shot through the head and with a pistol in his hand, what more rational than a verdict of suicide? But in real suicide the weapon is held so firmly that force is required to dislodge it. It seems as if the muscular spasm persists until rigor mortis occurs and sets it. Several experts have tried to make the hand of a corpse grip a weapon, but have never succeeded and their knowledge of this fact has often opened the avenue to detection of murder. Again, if you found your grandfather on the floor with a rope round his neck and the other end dangling from a nail in the wall, certainly you would say that he had hanged himself and his weight had broken the rope.

But the medico-legalist is as well up in knots as a sailor and knows a suicide will tie them one way, a murderer another. There was a case in Paris of a grandfather who had, apparently, hung himself in the manner described. But he had not tied the rope, declared the expert, and, in face of such uncanny knowledge, two neighbors confessed they had from their window seen the son-in-law strangle his father and arrange the other piece of rope.

A would-be murderer might advantageously study physiology, i. e., the physiological action of certain substances on the human body and might also, if he intends hiding the corpse, read concerning flora and fauna in the dead. The advice of Moquin-Tandon, sometime professor of Natural History in Paris University, was often asked by legal doctors because he had made a special study of the latter. The body of a little girl was found tightly packed up in a soap box, and the mother, when found in another city, tried to fix the crime on a friend and as happening two months ago. It was then the end of July. By a careful study of the flies and larvæ found in the remains, the expert proved the body to have been in the box since the preceding February and the mother confessed to having killed the child on February 27th. In the same way the examination of the larvæ on the body of a child hidden up a chimney proved death to have taken place fully two years previously, and this verdict led to the acquittal of a suspected person. There are certain fauna which begin their work soon after death, then disappear to give place to others, but the succession is invariable and marks time for the scientist.

The different physiologic action of fire on a dead body

* The *Alienist and Neurologist.*

and a living one was not known by the man who rushed frantically to his neighbors, saying he had found his wife lying across a chair by the fire badly burned from waist to knees and also on the neck. Unfortunately for him the doctor pointed out that burns made before death contained serum and there was no vesication (thin serous fluid under the skin), moreover, the fire could not have passed from waist to throat. The man then confessed to strangling his wife and afterwards setting fire to her.

The student who murdered his aged uncle by drowning had clearly not taken chemistry in his studies or he would not have been so confounded when brought to justice. He had wound nine yards of thick lead tubing round the body to sink it. Surely enough? But a little knowledge of chemistry would have made him make a few incisions for the escape of natural gases, as these brought up the corpse in spite of the heavy weight.

Lynx-eyed Science is rendering it ever more difficult to dispose of a body or hide the crime of murder. Human blood and hair and bones have characteristics distinctly their own. The "gory knife" of melodrama is no longer sufficient to fix a crime, and even if, as seems possible, the penny novelettist should kill his hero with radium, why, the physicist would come along with the electroscope and with it absolutely refute or confirm the accusation.

Rubber Roads a Future Possibility

THE connection between rubber and engineering is closer than the casual observer might suspect. It is safe to say that if rubber were deleted from the list of materials used in engineering work many phases of the industry would come to a standstill.

The first stoppage that would occur would be in connection with the manufacture of electrical plants. There is nothing to surpass rubber as an insulating material, and thousands of tons of rubber are used annually for this purpose in cable construction and in the production of electrical machinery of all kinds.

The road engineer of the future is a still bigger potential user of rubber, however, than the permanent way engineer. Rubber roads, though they may not be immediately practicable, are almost certain of ultimate adoption. But before the rubber road "arrives" a great deal of "missionary" work has to be done. At present engineers responsible for the upkeep of our roads fight shy of the rubber road proposition. Though it may be possible to calculate what a rubber road will cost, there is no definite and authoritative information available as to how long such a road will last under varying climatic conditions. It is useless to expect a local or other authority to consent to the laying down of stretches of rubber road at $25 per square yard unless they are quite convinced of the life that they may reasonably expect to get out of the road.

It is for the purpose of obtaining such information as will be required by road engineers that the Rubber Growers' Association has made a free grant of 1,000 tons of plantation rubber and has offered an additional 1,000 tons at the nominal price of 25 cents per pound during the next five years. The rubber will be used in the first instance on difficult roads in order definitely to ascertain its merits.

Already the association has taken practical action by awarding its gold medal to Mr. M. M. Dessau for his successful piece of experimental rubber roadway as laid down in the Old Kent Road. In Mr. Dessau's system Jarrah wood blocks are used with a surface cushion of rubber, held tightly in position by dovetailing. The blocks are readily movable, an advantage in these days of frequent subterranean excavations by electricity, gas, water, telephone, telegraph, hydraulic power, and other corporations. They interlock perfectly and give an absolutely water-tight joint such as cannot conveniently be obtained in any other way. This prevents the ingress of moisture and the consequent damaging of the road foundations.

It is claimed that the latter do not require to be nearly so strong in the case of rubber roads as with ordinary wood blocks. The reason is that the vibration of the heavy traffic on the latter causes the concrete foundations to disintegrate even if the thickness of the concrete is in excess of the now frequently adopted 12-inch standard.

The fact that thinner foundations can be used with rubber roads can be set against the extra cost of the rubber blocks, though even then the costs will not be equal, but the life of the rubber road may be expected to be so much greater as to more than compensate for the extra cost, apart from the advantages of silence and the prevention of skidding and side-slip of vehicles. The latter claim may at first sight appear a somewhat remarkable one, but it is a fact that the rubber road sections that have already been laid have proved to be most effective "non-skids." Even when covered with oil, or when blackleaded, the rubber road does not appear to cause motor vehicles to slip. This was hardly expected when the first sections were laid down. In fact, so convinced were insurance experts that the risk of disaster through side-slip on rubber roads was enormous that they quoted absolutely prohibitive rates when one section was being laid down, and a guarantee had to be given to the local authority. Now the premium is just the same as would be the case for any other road; in fact it is no longer necessary to insure. Here is a case of "the proof of the pudding," to be sure. And further proof will be forthcoming in due course as to the lasting quality of the rubber road.

The section in the Old Kent Road, after carrying for 295 days some of the heaviest traffic in London, amounting to ninety tons per square foot per hour for twenty-four hours, was not perceptibly worn, whereas an adjacent 4-inch wood block lost ½ inch in thickness in the same time under the same load.

Besides the South London experiments, trials are shortly to take place actually in the city. The corporation has granted the necessary permission to the acting agent of the Federated Malay States government to lay down a section of rubber roadway in Cannon Street, E.C., where the traffic is very heavy, and where its effect on the road can conveniently be observed by all interested in this new development.

There are clearly great possibilities in front of the rubber road, and as soon as its merits have been conclusively proved and accepted we should be within a reasonable distance, if not of the universal rubber highway, at least of the rubber road for special traffic conditions, with a resulting consumption of raw material that should make all rubber shareholders rejoice.—*The Daily Telegraph.*

Aircraft in War

THE decisive influence of reconnaissance by aircraft has already made itself felt during these stages of the war. Within a week of the outbreak of hostilities the French general staff possessed definite and accurate information regarding the exact position of every single army corps massed along the German western frontier and occupying Belgium.

Apart from the general effect exerted upon the conduct of hostilities by aircraft—an effect which cannot yet be precisely estimated, although its influence is already perceptible—several specific instances of the useful employment of aeroplanes have been reported. Events have proved that rifle fire is largely ineffective against aeroplanes, which, traveling swiftly, offer a very difficult target; the planes may be struck repeatedly by bullets, but, unless hit in a vital spot, such as the engine or the propeller, an aeroplane, even though riddled with shot, could continue its journey with its efficiency scarcely impaired.

With shell fire the case is different; a fragment of a shell striking an aeroplane would, in the majority of cases, inflict irreparable damage and bring it down to earth. On the other hand, an aeroplane traveling at a great height and moving at sixty miles an hour or more forms a most elusive target, and it is only when the necessity for detailed observation causes the pilot to fly low that the ordinary artillery, incapable of high angle fire, has a reasonable chance of bringing an aeroplane down. Experience has shown that an aeroplane pilot can only make accurate observations of the movements and positions of troops from a height not exceeding 4,000 feet, at which altitude it is within range both of rifle and shell.

The official statement that a French aeroplane reconnoitering over German territory in the Lorraine region was pursued by two German machines, but succeeded in escaping, and returned safely to the French lines, is interesting in that it proves that the light, fast French aeroplanes can without difficulty elude the more ponderous and slower German machines.

The bombardment of the fortress of Vesoul and the town of Lure by a German aeroplane confirms the opinion generally held by experts that the small bombs which alone can be carried on an aeroplane are incapable of doing serious damage. In each case the railway station formed the target, and was repeatedly struck, but the damage done was only slight and easily repaired. No aeroplane carries a flag, but the French machines bear on the underside of each wing a large Tricolor formed of concentric circles, in order that they may be identified and not fired upon by their own troops.—*The Daily Telegraph.*

Earthquakes and the Phases of the Moon

No regular periodicity of earthquakes has yet been demonstrated. The Italian seismologist, Cancani, thought that the great earthquakes of the Adriatic region recurred at intervals of one hundred years, but Agamennone and Cavasino proved, by a more critical examination of the records, that this supposed regularity does not exist.

In Japan the frequency of earthquakes has not varied in seven centuries. The earthquake statistics for the entire world since 1850 show that the number of destructive shocks (megaseisms) has remained nearly constant, at about thirty-one per year. From Milne's catalogue of megaseisms Montessus de Ballore has proved that the frequency of earthquakes bears no relation to the seasons or to the dry and rainy periods determined by Brueckner.

Dr. Otto Klotz, of the observatory of Ottawa, Canada, has classified in accordance with the phases of the moon the 465 shocks recorded at Ottawa from April, 1908 to December, 1913. He finds that, of each 100 earthquakes, 26.2 occurred at new moon, 23.0 in the first quarter, 22.4 at full moon, and 28.4 in the last quarter.

The differences in earthquake frequency in the four phases are considerable, but a much larger and more extended mass of concordant statistics would be required to prove the existence of a physical relation between earthquakes and the phases of the moon.—*Cosmos.*

A Correction

IT has been called to our attention that the name of one of the authors of the article on "Experimental Plotting of Electro-static Fields" on page 216 of the issue of October 3rd, was wrongly spelled Querbocker, when it should have been S. H. Querbacker. The error was caused by illegibility.

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